THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

INCLUDING THE TRANSACTIONS OF THE SOCIETY

JULY · 1914

A HIGH STANDARD OF MEMBERSHIP

THE VALUE of membership in any organization may be judged by its requirements for admission to membership. The Society is constantly striving to advance the engineering profession and to include among its members only those having the very highest qualifications.

At the Spring Meeting several changes in the requirements for admission became effective which should prove an incentive to all engineers to coöperate with the Society and which will enhance the value of membership to those already enrolled.

The requirements for the various grades are now as follows:

A *Member* shall be an Engineer or Teacher of Applied Science of thirty-two years of age, or over, and shall have been in the active practice of his profession for at least ten years and in responsible charge of important work for five years, and shall be qualified to design as well as to direct engineering work. Fulfilling the duties of a Professor of Engineering who is in charge of a department in a college or school of accepted standing shall be taken as an equivalent to an equal number of years of active practice. Graduation from a school of engineering of recognized standing shall be considered as equivalent to two years of active practice.

An *Associate* shall be thirty years of age or over. He need not be an Engineer, but must have been so connected with some Branch of Engineering or science, or the arts, or industries, that the Council will consider him qualified to cöoperate with Engineers in the advancement of professional knowledge.

An *Associate-Member* shall be a professional engineer not less than twenty-seven years of age, who shall have been in the active practice of his profession for at least six years, and who shall have had responsible charge of work as principal or assistant for at least one year. Graduation from a school of engineering of recognized reputation shall be considered as equivalent to two years' active practice.

A *Junior* shall be twenty-one years of age or over. He must have had such engineering experience as will enable him to fill a subordinate position in engineering work, or he must be a graduate of an engineering school.

The Member grade is now more strict in its requirements than that of any other engineering society in America and the Associate-Member grade is one of dignity and is a professional grade intermediate between the Junior and Member grades.

The Associate is non-professional and is intended to provide opportunity for executive officers of industrial enterprises and others who because of their association with engineers desire to coöperate with the Society in the advancement of professional knowledge.

A brochure has been issued for distribution to those who desire complete information regarding the work of the Society.

Total Membership of the Society, June 20, 1914 .... *5639*
New Members since January 1, 1914 .... *412*

THE JOURNAL OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

Volume 36 JULY 1914 Number 7

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ANNUAL MEETING IN DECEMBER 1914

THE Annual Meeting of the Society will be held in New York December 1–4. The feature of the meeting will be a session extending throughout the day on Thursday, December 3, on the general subject of the Engineer in Public Service, taking up also problems in municipal engineering which are of interest to the mechanical engineer. It is planned to have a session on Aviation, one devoted to Engineering Metals, particularly Steels of Construction and for Tools; Cast Irons; and Alloys of Copper, Tin and Aluminum, etc. The sub-committees on Railroads and Machine Shop Practice are planning for sessions and there will undoubtedly be groups of papers given under the direction of other committees, besides one or two sessions at which miscellaneous papers will be read. *It is urged that all papers for the Annual Meeting be sent to the Secretary not later than September 1, and that those who contemplate contributing papers notify the Secretary in advance of this date if possible.*

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Volume 36 July 1914 Number 7

THE SPRING MEETING

Those in attendance at the Spring Meeting at St. Paul-Minneapolis expressed great satisfaction at the reception which the Society received and were enthusiastic at the results achieved through the untiring efforts of the Local Committee, Max Toltz, chairman. The entire convention not only afforded much pleasure to the visitors but was of real value to the profession. The meeting comes to a close as this number of The Journal is going to press and the various events will be referred to in a subsequent issue.

The registration started on Tuesday afternoon, June 16, a large party of the members from the East arriving on the special train at 4 o'clock. On Tuesday evening there was a reception and addresses of welcome were delivered by Governor A. O. Eberhardt, representatives of the Chamber of Commerce, and the Mayor of St. Paul, the evening closing with dancing and refreshments.

At the Wednesday morning business meeting the overshadowing event was the discussion upon the subject of Boiler Specifications. A tentative draft of the Committee's recommendations had been printed so that its work might be checked up and revised before the report is submitted for general discussion. There had been a meeting at Chicago on Monday, attended by representatives of the Association of Steel Manufacturers, the Association of Tubular Boiler Manufacturers, and the Boiler Specifications Committee of the Society, at which there was discussion with regard to the steel specifications; this discussion was continued at the opening session on Wednesday morning. The result was a resolution calling for a public hearing to be held in the rooms of the Society in New York on September 15, 1914, to which all interests would be invited and that those desiring to participate in this hearing should submit their criticisms and suggestions in writing prior to August 10. At this session also the revised report of the Flange Committee was received and the Committee discharged with the thanks and appreciation of the Council.

Following the business meeting was a discussion of the papers on Powdered Fuel, which were well received. The subject is a timely one, and besides the written discussion there was a considerable amount of opinion contributed from the floor. The second session in the afternoon was, as would be expected, not so largely attended, although the papers drew out a fair amount of discussion. In the evening the lecture on Ore Handling, by John Hearding, superintendent of the Oliver Iron Mining Company, Duluth, was a great success and was attended by an audience of 300. A number of reels of films were run off by Mr. Hearding and described by him in a most interesting manner. He showed all phases of iron mining work on the Mesaba Range from the rough mining methods in the pit up to the shipping of the ore and its chemical analysis.

On Thursday the visiting members were conducted on special cars to the University of Minnesota buildings, where the concluding professional session was held. Fred B. Snyder, Senator and member of the Board of Regents of the University, made an opening address, and Prof. H. T. Eddy of the faculty also addressed the meeting. The Engineering Developments of the Northwest were treated in the three papers presented, which had been secured by the Local Committee. These brought out some discussion, although the large number of excursions in progress at the same time limited the attendance. A luncheon was given at noon in the Experimental Engineering Building, 250 sitting down to the tables. A resolution of thanks to the Local Committee and to all who had contributed so greatly to the success of the meeting was read at its conclusion.

Immediately after luncheon the members and guests went by special train to the residence of Mr. Gebhard Bohn on Lake Minnetonka, being met at the station by launches and conducted to the Bohn residence. Here an elaborate program, including daylight fireworks, dancing, and entertainment by a cartoonist and other professional performers, had been provided. Much amusement was afforded by caricatures of the

members of the Council present as well as of the local celebrities. Tea was served about 6 o'clock, followed by dancing.

After the close of the convention on Friday, about forty members availed themselves of the splendid invitation extended by the members of the Society in Duluth to visit that city. T. W. Hugo came to the convention personally to urge the members to accept their hospitality. Upon the arrival of the visitors at 7.30 they were taken on a trip around the harbor and on Saturday morning were given an opportunity to view the large ore-handling apparatus of the city.

COUNCIL NOTES

At the meeting of the Council held in St. Paul on June 16, the report of the Committee on Flanges was received, and at their request the Committee was discharged, and the Council spread upon its minutes its appreciation of the splendid work which has been performed by the Committee, especially its chairman, H. G. Stott.

It was voted to amend By-Law 2 as follows:

Applications for membership from candidates who may be so situated as not to be personally known to the necessary number of members of the Society, as required in Paragraphs 1 and 2, may be recommended by the Membership Committee for ballot, after sufficient evidence has been secured to show that in its opinion the applicant is worthy of admission to membership. Such applicant for membership may refer to officers or voting members of other engineering societies of like standing.

The formation of a Student Branch at Worcester Polytechnic Institute was approved.

Numerous requests were received by the Council from national organizations for opportunity for conference with regard to Boiler Specifications, and a public hearing was ordered for September 15 in the rooms of the Society, when all bodies interested in the development of a boiler code were cordially invited to be present and participate in the preparation of the code.

Several communications received from members of the Society were read in full to the Council, urging that the bound volume of Transactions be issued as usual, because of its being highly prized by the membership, although they have promptly received all the material and more in the monthly issues of The Journal. The Council considered these requests favorably and will communicate with the members of the Society later regarding them. The Council would state that The Journal is self-supporting and under no expense to the Society, and is therefore not subject to discussion, as the members' dues in no way contribute towards it. The continuance of Transactions means that other activities of the Society which the Council had considered of more value to the membership than the duplicate publication in Transactions will, of course, have to be abandoned.

The matter of issuance of advance copies of papers to be read at conventions was discussed, and notwithstanding the fact that out of the entire membership only six requests for advance copies of papers had been received, the Council voted that hereafter a reply postal, or its equivalent, would be mailed to every member of the Society so that there could be no possible opportunity for criticism because of the failure of any member to receive gratis copies of every paper that he actually needs previous to any meeting of the Society.

Calvin W. Rice, *Secretary.*

MEETINGS OF THE YEAR

With the close of the spring meeting at St. Paul and Minneapolis and the holding of the last monthly meeting of the season on June 3 in St. Louis, the 1913-1914 season ends for the meetings of the Society. Since the opening of the Society year last October, 54 meetings have been held in 14 different cities, besides the annual and spring meetings in New York and St. Paul-Minneapolis respectively. This is a substantial increase over any previous year, and when it is realized that as recently as 1907 the only local meetings were the six New York meetings occuring during the winter months, it can be seen how much greater is the present opportunity for the membership to get together.

In general the local meetings have been well attended and many papers of extraordinary interest have been presented. Everywhere the spirit of coöperation has been predominant since nearly one-half of all the meetings throughout the country have been joint sessions with other societies. In a number of cases the usual procedure has been varied by some exceptional undertaking as, for instance, at Worcester, an afternoon and evening convention held by the Boston members in coöperation with the local members at Worcester; or at New York, where one of the most important meetings of the year was in connection with the Sub-Committee on Railroads, with a paper on the famous Pennsylvania Railroad air brake tests; or at New Haven, where regularly quarterly conventions are held.

During the past year meetings have been begun at Atlanta, Buffalo, Milwaukee and at St. Paul and Minneapolis. At Atlanta, the membership is small, but the members are working enthusiastically to increase the interest in the Society and one joint meeting with other engineering organizations has been held. At Buffalo and Milwaukee some work of organization had been done previous to the present year when the meetings have at last become a regular feature. At Buffalo there have been four meetings, the first of which was addressed by President Hartness, and at Milwaukee an excellent general organization has been effected known as the Engineers Society of Milwaukee, comprising representatives of five engineering societies with a Board of Managers. Four meetings have taken

place, at one of which there were afternoon and evening sessions. At St. Paul and Minneapolis there have been three meetings held alternately in these two cities under the direction of the Minnesota Committee, besides the special session at the Spring Meeting when papers upon local engineering subjects were given, arranged by the Local Committee.

It is altogether probable that other cities will join the ranks of those holding Society meetings from year to year, emphasizing more and more the national character of the Society and incidentally making an increasing return to the membership as a result of this increasing service to the profession.

INTERNATIONAL ENGINEERING CONGRESS, 1915

The attention of the engineers of the world is being more and more drawn to the program of the International Engineering Congress which is to be held in San Francisco, California, in 1915. The interest which has been aroused in foreign countries is shown by the fact that at the present time there have been received enrollments and subscriptions from 42 such countries. It is furthermore to be noted that of the present total enrollment, approximately 25 per cent is from countries other than the United States. The number of subscriptions from the members of the five national engineering societies of the United States under whose auspices and control the Congress is being held is, however, not so gratifying. The percentage of the total membership of these five societies represented by the subscription list is only 3.7, and this, although each individual member of these societies has received circular information and data concerning the Congress and has been urged to send in his subscription promptly.

It is probable that this is largely due to the fact that the date of the Congress is still somewhat in the future, and also to the tendency of the individual to procrastinate. This, to a considerable degree, handicaps the work of the Committee on Management, and it is extremely desirable that as many as possible who intend to subscribe should do so at an early date.

The list of topics to be treated in the Section on Mechanical Engineering gives a very good idea of the character of the publications which it is intended to issue and the topics which will be presented and discussed at the meeting. These are as follows:

(1) Recent progress and present status of foundry practice, and casting metals
(2) Recent progress and present status of the art of forging
(3) Equipment processes, and methods for the boiler-shop
(4) Machine-shop equipment, methods, and processes
(5) Automatics
(6) Special processes for shaping and forming metals
(7) High temperature flames in metal-working
(8) Industrial management
(9) Safety engineering
(10) Industrial Museums as an educational factor
(11) The steam-engine of the year 1915
(12) The steam-turbine of the year 1915
(13) The internal-combustion engine of the year 1915
(14) Motors of the Diesel type
(15) The Humphreys gas pump
(16) The steam boiler of the year 1915
(17) Refrigeration
(18) Pneumatics
(19) Lubrication and lubricants
(20) Water wheels of pressure type
(21) Water wheels of impulse type
(22) Hydraulic power developments and use
(23) Power-plant design
(24) Motor vehicles, passenger type
(25) Motor vehicles, utility type
(26) Motor tractors

Many of these topics will be treated as symposiums with contributions representing the practice in more than one country.

The various sections outlined for the work of the Congress and the volumes to be issued are as follows:

Vol. I	The Panama Canal
Vol. II	Waterways and Irrigation
Vol. III	Municipal Engineering
Vol. IV	Railways and Railway Engineering
Vol. V	Materials of Engineering Construction
Vol. VI	Mechanical Engineering
Vol. VII	Electrical and Mechanical Engineering
Vol. VIII	Mining Engineering and Metallurgy
Vol. IX	Naval Architecture and Marine Engineering
Vol. X	Military Engineering, and Miscellaneous

It will be noted that the proceedings of the Section on Mechanical Engineering will be published in Vol. VI, with some of the papers falling into Vol. VII. It is also noted that Vol. X will consist only in part of Military Engineering and will also contain papers on miscellaneous topics which are not definitely associated with any of the various sections.

Full information concerning the Congress may be obtained by addressing the Committee of Management as follows:

INTERNATIONAL ENGINEERING CONGRESS, 1915,
Foxcroft Building, San Francisco, Cal.

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i.e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. The Membership Committee, and in turn the Council, urge

the members to assume their share of the responsibility of receiving these candidates into the membership by advising the Secretary promptly of anyone whose eligibility for membership is in any way questioned. Members will be furnished with complete records of any candidate thus questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before August 10, 1914.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Allman, Wm. N., Engr. & Draftsman, Baltimore & Ohio R. R. Co., Baltimore, Md.

Bailey, Ledyard M., Genl. Mgr., Portland Cement Co. of Utah, Salt Lake City, Utah

Barker, John P., Supt. & Ch. Engr., Homer Motors Co., Los Angeles, Cal.

Bell, Wm. L., Mgr., Fulton Engine Works, Los Angeles, Cal.

Berry, Arthur O., Senior Mech. Engr., Interstate Commerce Commission, Division of Valuation, Chattanooga, Tenn.

Cooke, Horace G., Mgr., Eastern Office, The Connersville Blower Co., New York.

Davis, Oliver M., Mech. Engr., Constr. Dept., Swift & Co., Chicago, Ill.

Frear, Jenness B., Asst. Supt., Park Mfg. Co., Minnesota Transfer, Minn.

Hoagland, Ira G., Secy., Natl. Automatic Sprinkler Association, New York.

Jakowleff, Dmitry, Asst. Ch. Engr. for Construction of the Ladoga Water Supply, St. Petersburg, Russia.

Luster, Emile J., Mech. Engr. & Sales Mgr. with Alfred H. Schutte, New York.

Miller, Alten S., Member of Firm, Humphreys & Miller, Inc., New York.

Oleson, Olaf E., Ch. Engr., Fisk & Quarry St. Stations, Commonwealth Edison Co., Chicago, Ill.

Pilkington, Robert G., Resident Engineer, American Efficiency Survey of Motor Car Units, Chicago, Ill.

Purves, John B., Mech. Engr., Combined Locks Paper Co., Combined Locks, Wis.

Schreck, H., Asst. Ch. Engr., Diesel-Engine Div., Fulton Iron Works, St. Louis, Mo.

Schreiber, Carl T., Publicity Engr., Hill Publishing Co., New York.

Spitzglass, Jacob M., Engrg. Dept., Peoples Gas Lt. & Coke Co., also Pres., Gebhardt Meter Co., Chicago, Ill.

Sweeney, Matthew M., Production Engr., Genl. Fire Extinguisher Co., Providence, R. I.

Thanisch, Rudolph J., Asst. Engr., Bridge & Ferry Div., City of Boston, Mass.

Wilcox, Robert B., Supervising Engr., Dept. for Inspection of Steam Boilers, Steam and Cooling Plants, City of Chicago, Ill.

Williams, Charles H., Master Mechanic, New River Collieries Co., Eccles, W. Va.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Alling, Claude R., Asst. Engr., Underwriter's Laboratories, Inc., Chicago, Ill.

Brown, Alexander C., Vice-Pres., The Brown Hoisting Mchy. Co., Cleveland, Ohio.

Cady, Ceylon R., Ch. Engr., Douglas Co., Cedar Rapids, Iowa.

Cottrell, Joseph F., 2nd Lieut., Coast Artillery Corps, U. S. A., Corregidor Island, P. I.

Davis, Royden N., Mech. Engr., The Peoples Gas Lt. & Coke Co., also Cons. Engr., Indiana Gas & Oil Co., Chicago, Ill.

Horst, Anton E., Secy. & Treas., Henry W. Horst Co., Rock Island, Ill.

Mann, Howard L., Factory Mgr., Chicago Pneumatic Tool Co., Chicago Heights, Ill.

Morgan, Edward J., Engr., Alberger Pump & Condenser Co., Chicago, Ill.

Staniar, Wm., Special Mech. Engr., E. I. du Pont de Nemours Powder Co., Wilmington, Del.

Wing, Chester E., Asst. Engr., The G. M. Parks Co., Fitchburg, Mass.

FOR CONSIDERATION AS JUNIOR

Atwater, Harry A., Mech. Engr., Union Stock Yard & Transit Co. of Chicago, Chicago, Ill.

Baxter, Henry N., Designing Engr., Lyons Atlas Co., Indianapolis, Ind.

Bissell, Albert W., Draftsman, Link-Belt Co., Chicago, Ill.

Burrell, Gene N., Asst. Resident Engr. on Diversion Dam of Inter County Improvement, Tacoma, Wash.

Butler, Roland G., Asst. to Ch. Engr. of Elec. & Mech. Depts., Central Illinois Public Service Co., Mattoon, Ill.

Cozzens, Henry A., Jr., Laboratory Asst., Public Service Elec. Co., Newark, N. J.

Dawson, Val. S., Supt., Fidelity Cotton Oil & Fertilizer Co., Houston, Texas.

Dougherty, John H., Centrifugal Engr. & Salesman, The Jeanesville Iron Works Co., Hazleton, Pa.

Kinsman, Richard E., Engr. & Accountant, American-La France Fire Eng. Co., Elmira, N. Y.

Macnoe, George, Draftsman, Power Specialty Co., Dansville, N. Y.

Markey, Harold L., Asst. Instr. in Mech. Engrg., University of Michigan, Ann Arbor, Mich.

Nicoll, Wm. L., N. Y. Representative, Lockwood, Greene & Co., New York.

Peets, Wilbur J., Mech. Engr., Singer Mfg. Co., Elizabethport, N. J.

Porter, LaFayette L., with Root and Van Dervoort Engrg. Co., East Moline, Ill.

Reitz, Walter R., Asst. to Mech. Engr., Burdett-Rowntree Mfg. Co., Chicago, Ill.

Taylor, Sutherland G., Jr., Ch. Engr., Installation Dept., Slocum, Avram & Slocum, Inc., New York.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE

Waite, Edward B., Dean and Head, Consulting Dept., American School of Correspondence, Chicago, Ill.

PROMOTION FROM JUNIOR

Davis, Herbert R., Supt. of Production, Quapaw Gas Co., Wichita Natural Gas Co., and Wichita Pipe Line Co., Bartlesville, Okla.

Fisher, Henry D., Asst. Mech. Engr., Fuel Testing Co., Boston, Mass.

Price, Wm. T., Ch. Engr., Oil Eng. Dept., De La Vergne Mch. Co., New York.

SUMMARY

New applications	48
Applications for change of grading	
Promotion from Associate	1
Promotion from Junior	3
Total	52

BOSTON SYMPOSIUM ON SELECTIVE PACKAGE AND PNEUMATIC CONVEYORS

AT a meeting in Boston on April 8, three papers were presented on Conveying Systems. One of these by W. O. Hildreth related to conveyors adapted for delivering packages or other materials from a central station, or from intermediate stations, to various other stations as selected by the sender at the time the goods are despatched. A second paper by F. B. Williams illustrated particularly the tube systems for transporting mail, for long distances underground. A third paper by S. L. Haines dealt with belt conveyors in use for handling magazines in publishing establishments and with link-belt elevators for packages.

CONVEYORS OF THE SELECTIVE TYPE

By W. O. Hildreth,[1] Boston, Mass.
Member of the Society

Selective conveyors are conveyors adapted for delivering packages or other materials from a central station, or from intermediate stations, to various other stations as selected by the sender at the time the goods are despatched. While this definition may not entirely eliminate the plain belt conveyor with the usual trippers for distribution of a continuous stream of material, this paper is confined to the consideration of conveyors for transporting separate packages to predetermined stations.

The delivery of these packages at the proper station may involve merely some device to sweep the package from a moving conveyor belt, or may involve the switching of some standard tray or "tote box" to a station located at the side of the conveyor, or may involve the construction of a carrier with individual cars adapted for delivering loads at any one of a number of stations located along the path of the conveyor.

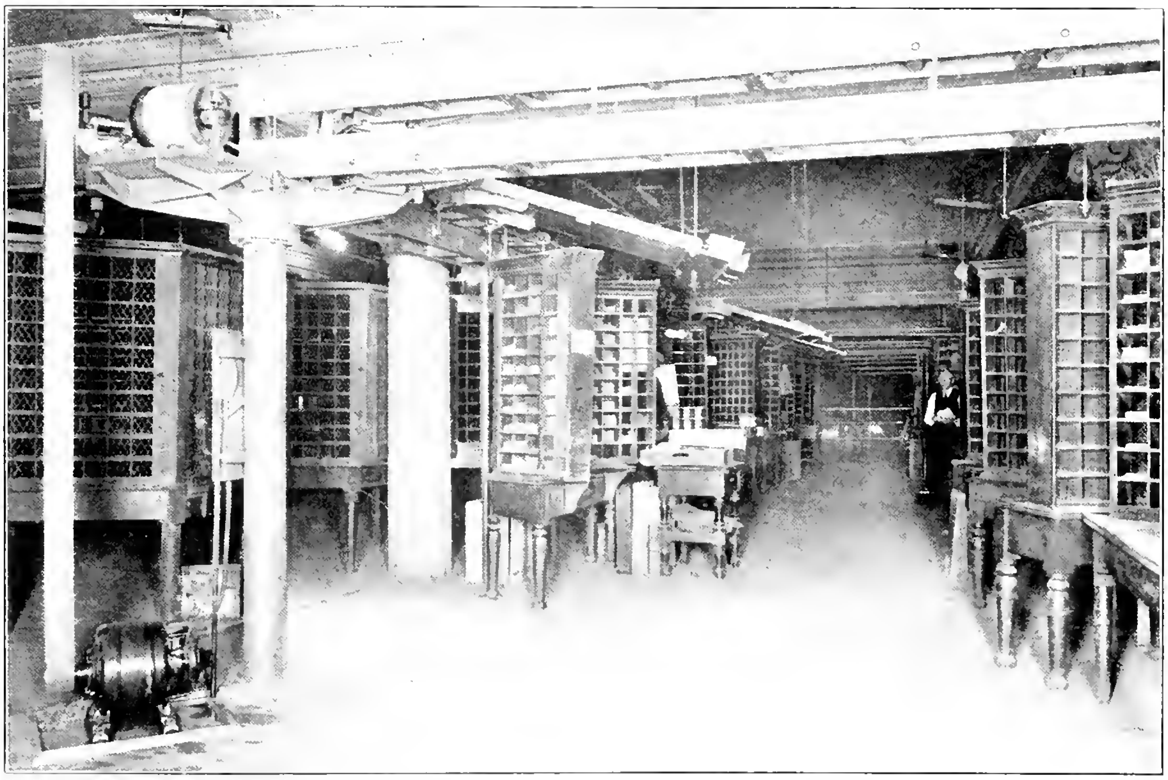

Fig. 1 A Tray Conveyor in use at the Philadelphia Post Office

Generally it is necessary to give service in both directions. With conveyors of the belt type this return service can be secured by the use of the lower or return part of the belt. With other types of carriers the conveyor may form a complete circuit so as to give

[1] Presented at the Boston local meeting of The American Society of Mechanical Engineers, April 8, 1914

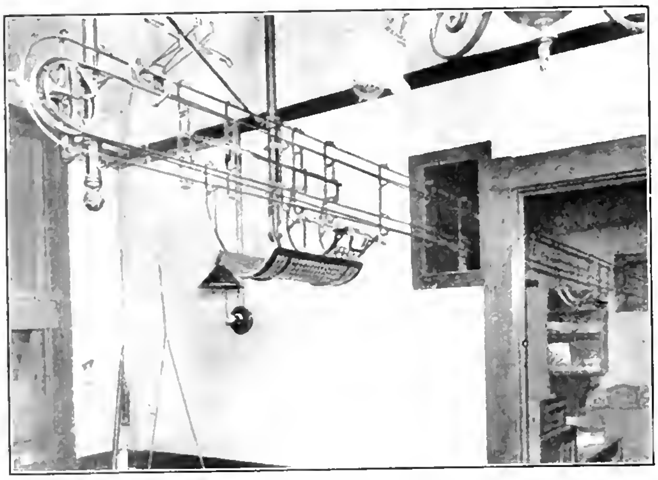

FIG. 2 VIEW OF A TYPICAL PICK-UP CARRIER SHOWING DETAILS OF A STATION

intercommunicating service, although materials may always travel in the same direction.

While the belt conveyor type has a certain amount of flexibility in a vertical direction, it can make horizontal turns only by the use of another conveyor and these limitations compel the use of some more flexible

One of the simplest methods for giving a series of separate deliveries to a number of separate stations located alongside a belt conveyor is to introduce a number of vertical stationary partitions above the moving belt so as to divide the conveyor into a series of divisions and then terminate these dividing plates successively at the various stations, at the same time leading the division plate to the edge of the belt so as to sweep off all material that is contained in this particular division.

Such a conveyor can be loaded at any intermediate point and the sender can determine the delivery point by placing his material in the proper division. It is evident that such a conveyor has all the limitations imposed by the use of a belt; nevertheless there is a considerable field of usefulness that can be served by such a device. It is well adapted for handling pass books in banks between tellers and bookkeepers, and for handling cards, order slips or papers that can be carried on edge between the division plates.

A modification of this carrier has been used in a number of telephone offices for conveying charge slips and toll line call slips. This modification retains the series of vertical division plates, but substitutes a smooth

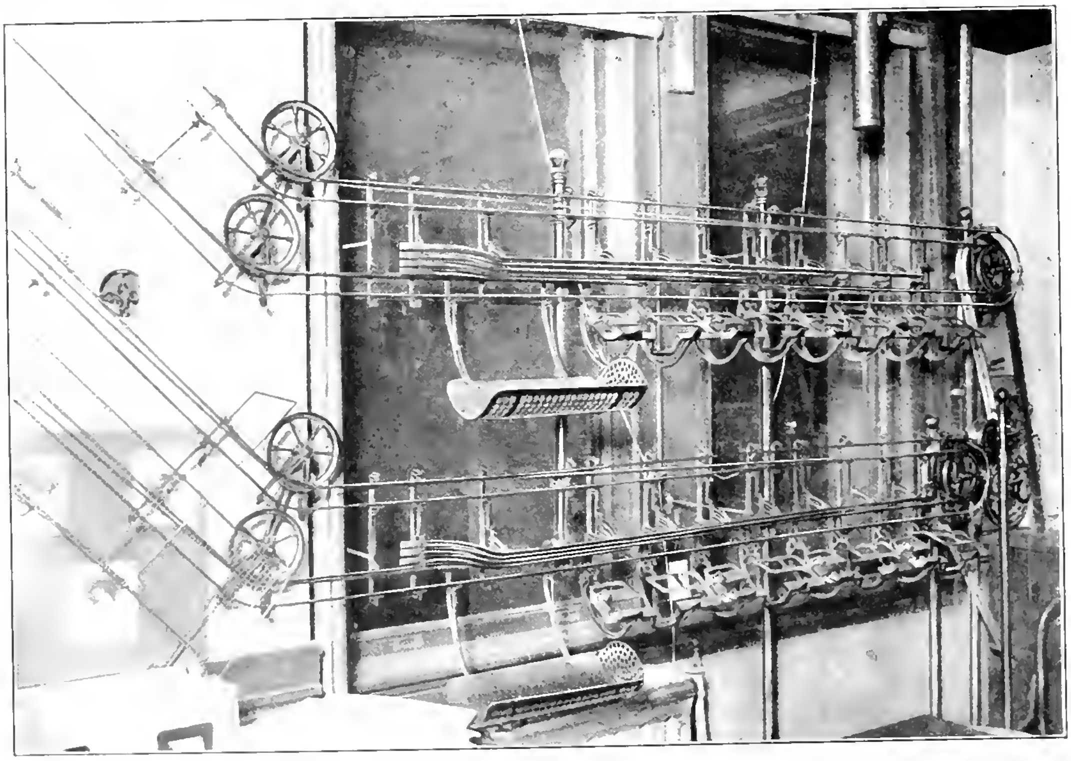

FIG. 3 VIEW OF SENDING STATION ON A PICK-UP CARRIER SYSTEM, SHOWING SELECTIVE MECHANISM FOR FOUR STATIONS

means of connection between the individual cars or other transportation units, if we are to cover satisfactorily all the requirements of the modern manufacturing plant. Such selective conveyors must give practically continuous service between points located on several different floors, and must be able to avoid various obstructions and reach points that could not conveniently be reached by a belt conveyor.

bottom plate for the moving belt. The tickets, which project above the division plates, are pushed forward by a horizontal finger attached to a car and driven by an endless cable. The car is guided on a track suspended above the division plates. It is possible, with this conveyor, to turn horizontal corners and to carry the slips from one floor to another by means of inclines which may be as steep as 45 degrees or more.

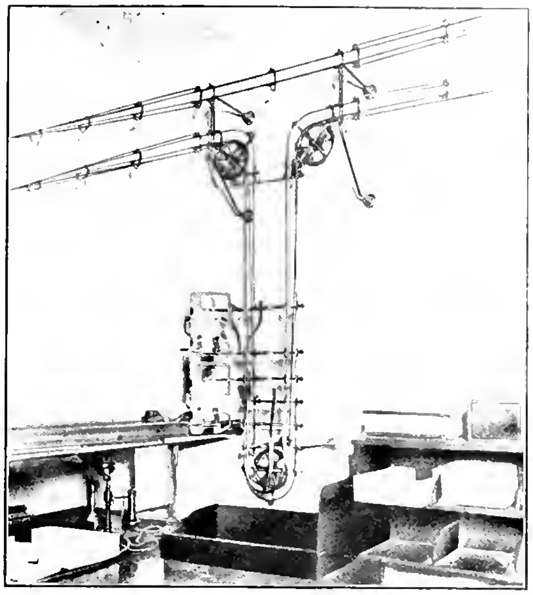

Fig. 4 A Vertical Sending Station on a Pick-up System, having Selective Mechanism for Two Stations

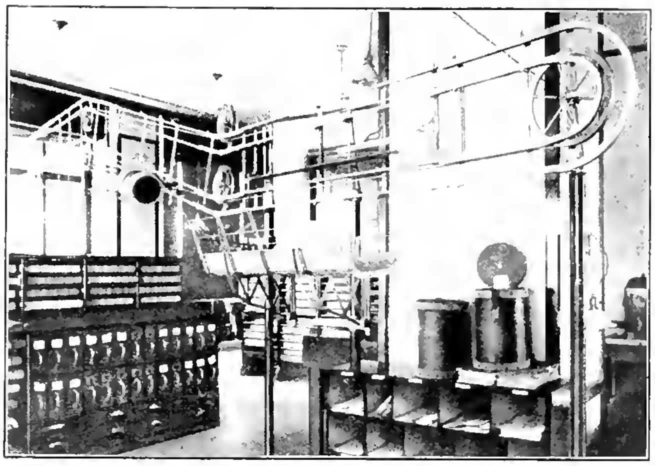

Fig. 5 A Pick-up System fitted with Large Cylindrical Carriers for Handling Large Envelopes and Bundles of Papers

This type of carrier with the moving belt has a considerable field for the distribution of materials that can be handled on a belt and swept from the belt at the delivering point.

Tray Conveyor.—The next step in the development of a selective conveyor, using a belt for the moveable conveying member, is what may be called a tray conveyor. The tray or tote box is in common use in manufacturing establishments for the transportation of small parts from one department to another. With this type of carrier the tray can occupy the entire width of the conveyor, thus cutting down the width of the permanent structure to a size just sufficient to accommodate one tray.

The carrying capacity of this type of conveyor is very large since there is a possibility of sending practically a continuous stream of trays and switching them to intermediate stations or to lines branching from the main trunk line of the conveyor at any point. The return service can be secured by the use of the returning portion of the belt and it is possible to send from any station on the line to any other station, thus giving intercommunicating service.

In this type of conveyor the tray is furnished with a moveable projecting finger, generally extending above the front end of the tray, and adapted for engagement with the switches which extend over the conveyor from the various stations. The selective finger on the tray is moved by the despatching operator to

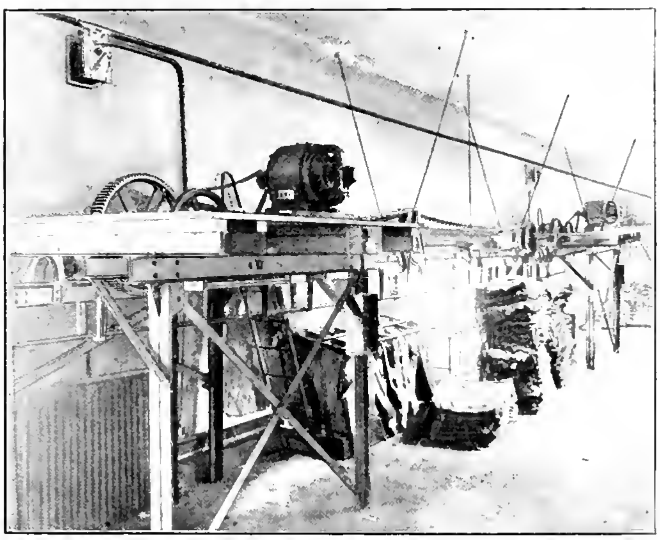

Fig. 7 The Driving Mechanism for the Bag Carrier System in the Chicago Post Office

Fig. 6 View of a Bag Carrier System in the Chicago Post Office, with Receiving Chute

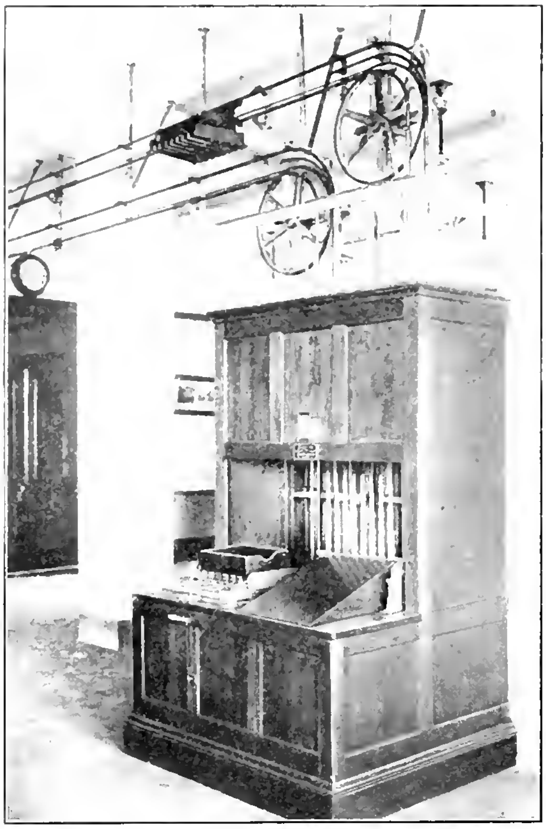

Fig. 8 View of a Station on a Typical Book Carrier System and a Car above en route

a numbered position corresponding to the station to which the tray is to be sent, and the tray is then placed upon the moving conveyor belt. The tray passes all the intervening switches until it reaches the station for which its selective finger is set, and after coming in contact with the switch it is deflected from the conveyor belt and delivered upon an inclined shelf, from which it is removed by the attendant.

Instead of switching to a station, the tray can if desired be switched to a branch line for delivery to stations located along this line. The width of the end of the tray, and the necessary spacing between successive positions of the selective finger on the tray, is the only thing that limits the number of stations possible on such a system. It is possible to cover more than one floor with one of these tray conveyors by transporting the trays on inclined conveyors from floor to floor, or by delivering the trays to automatic elevators, which in turn may deliver at any one of a number of different floors or to other belt conveyors with selective stations. A typical tray conveyor for Post Office work is shown in Fig. 1.

A further variation of this type of conveyor is made with a four-wheeled car propelled by an endless cable and running upon two rails. This car is provided with a cable gripping device that will disengage the car from the cable when the car is switched from the main line onto the switch track. The switch is operated by a selective finger on the car and the number of stations that can be used is limited only by the space available on the car for the selective switching positions.

A system of this kind, with automatic elevators onto which the cars are run and dropped several stories, has been in use many years in the Boston Public Library for transporting books from the stacks to the delivery desk. When cars are returned from the switch tracks to the main line, the moving cable is gripped automatically and the car proceeds until switched again from the main line at the station determined by the setting of the selective finger on the car.

While the capacity of this conveyor is not as great as the capacity of the tray conveyor, nevertheless it can handle a great amount of material with a very small expenditure for power. When cars are not actually en route, the power required for driving the cable is very small, the track is inconspicuous and does not obstruct the lighting of the shop at all.

Pick-up Carrier.—Another class of carriers that has been developed for the transportation of orders and correspondence, rather than for large quantities of manufactured material, is known as a "Pick-up Carrier" from the action of the car which actually picks up its load from a shelf upon which the load has been placed by the sender.

This carrier introduces a different principle of selection from those previously described, in that it has a series of cars permanently attached to an endless

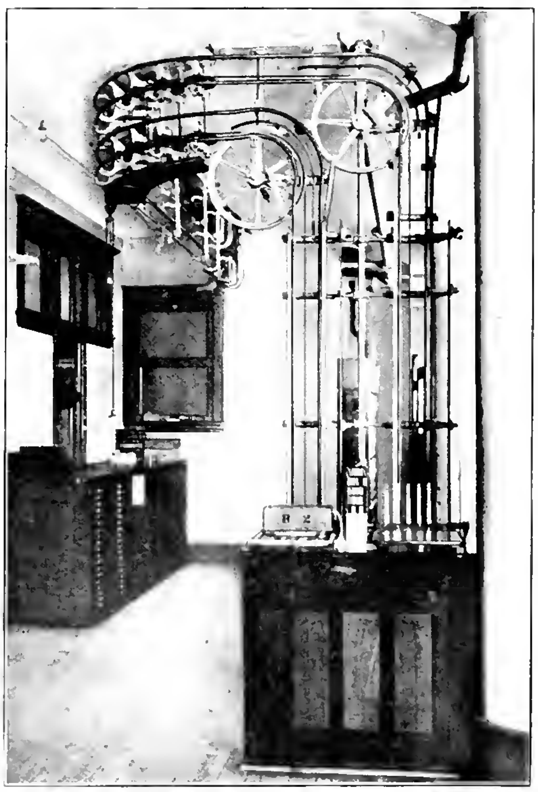

Fig. 10 Details of Construction of Vertical and Horizontal Turns in a Book Carrier System

driving cable and sliding upon a pair of smooth round steel rods. The cars are furnished with gripping jaws of steel wire adapted for holding either flat envelopes or cylindrical carriers. The upper jaw is stationary, while the lower jaw is moveable and swings around a fulcrum pin with a spring to press the moveable jaw against the stationary jaw and hold firmly whatever material may be contained between the jaws. The moveable jaw has a projecting arm that rides upon a cam surface at the station so as to open the jaws for delivering the load and to allow the jaws to close again upon another load waiting upon the sending shelf. A typical pick-up carrier is shown in Fig. 2.

As the different cars have opening levers of different lengths, it is possible to have a series of cars, each one opening its jaws for delivering and picking up messages at two definite locations along the line. A message placed upon a certain sending shelf will be picked up by its own car only and will be delivered always at another definite location where the station cam is placed in the correct position to operate this particular car and no other one. A series of sending shelves at a station gives the sending operator an opportunity to send to as many destinations as he has shelves, and every car that arrives at his station must drop its message for him before picking up a message for the other station. In Fig. 3, is shown a sending station for two systems with four stations each.

In this carrier the selective mechanism is a permanent part of the car, itself, and does not require any adjustment by the operator or by the station mechanism. The only selective effort required of the operator is to select the proper shelf upon which to lay his message and the carrier does the rest.

In order to keep the size of the car and stations within reasonable limits, it has seemed desirable to limit the cam graduations on a station to five so that it is possible to send from a central station to five other stations and to receive messages from these five stations in return. It is practicable to handle papers or traffic envelopes as large as 10 in. x 13 in. with this system, or in cylindrical carriers as long as 30 in. In Fig. 5 is shown a system of this kind.

As the cars are traveling continuously, service is provided from each station at regular intervals and as the sender does not have to wait for a car, but has only to lay his message on the proper shelf and return to his work again, the service is prompt and regular without waste of the sender's time. The messages are dropped by the cars into a single receiving pan or basket at each station.

In cases where it is desirable to have intercommunicating service between a large number of stations, it is customary to group the central stations of a number of lines at one convenient point and make this point a clearing house for the entire system by transferring the messages sent in by the different lines to the proper shelf for transmission to their final destination. This

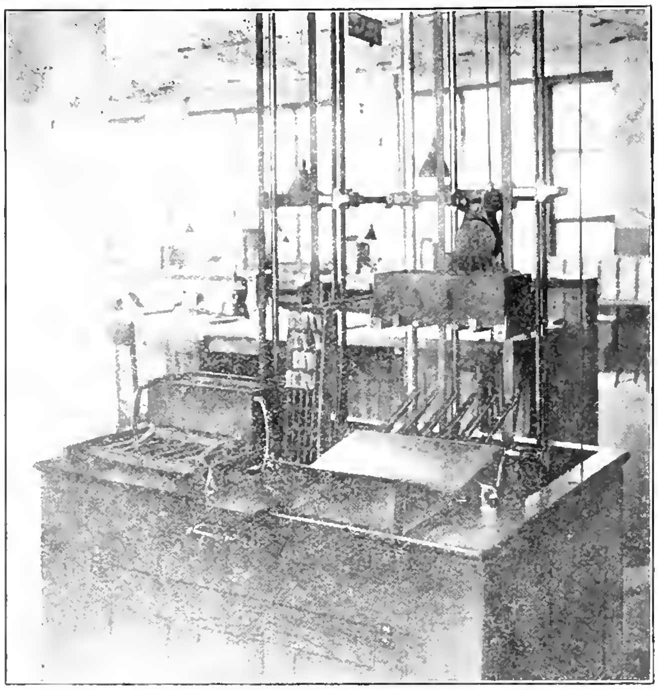

FIG. 9 A STATION OF DIFFERENT FORM ON A BOOK CARRIER SYSTEM WITH CAR APPROACHING RECEIVING FINGERS

work can usually be done by a filing clerk or some one permanently employed in the neighborhood of the station so that special help need not be employed for this particular purpose.

As this system is operated by a flexible cable, it is possible to turn corners in any direction so that stations on a number of floors can be served by a single line. The power consumption is small and the service is practically noiseless in operation.

BAG CARRIER.—Another carrier with a capacity for handling loads as great as 150 to 200 lb. has been developed along somewhat similar lines, but with a different principle of selection. As this conveyor was first used for transporting post office mail in bags, it has become known as a "bag carrier." It consists of a series of two wheeled cars or trolleys permanently attached to an endless moving steel wire cable at frequent intervals often as close as 10 ft. apart. The car wheels run upon the lower flanges of structural steel channels with a pair of guiding rails below the channels to prevent excessive swinging of the cars. A system of this type is shown in Fig. 6.

Each car has a hook upon which the bags are hung and these hooks are hinged in such a way that they can be tripped so as to drop the loads hung upon them. A moveable unlocking slide is arranged upon the car so that a selective finger on the car can be set at the sending station in as many different locations as there are delivery points on the line. This selective setting is done at the sending station as the car passes an inclined cam device whose position is controlled by the operator. This cam moves the unlocking slide and the

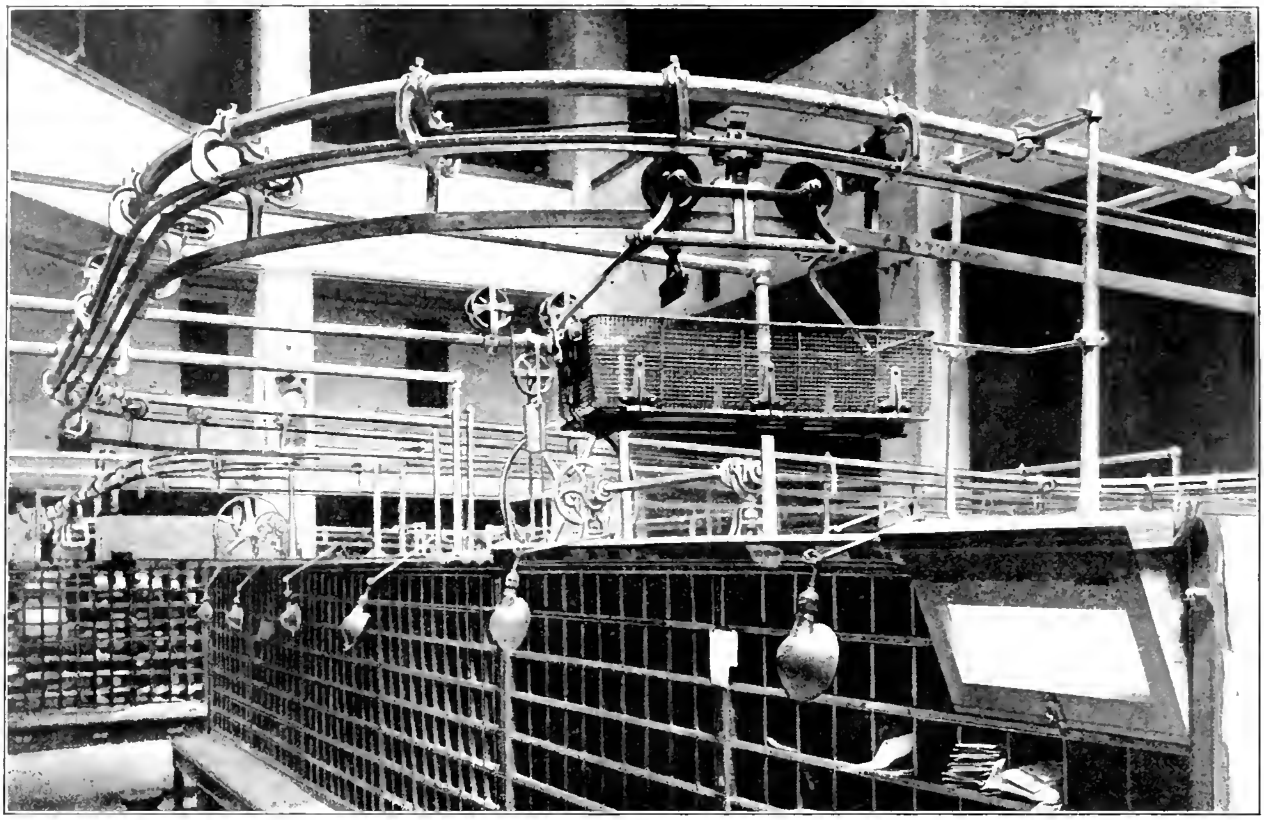

FIG. 11 VIEW OF SWEEP-OFF CARRIER SYSTEM IN THE CHICAGO POST OFFICE

selective finger to a position corresponding to the delivery station desired.

Each delivery station has a tripping finger permanently fixed at a different height from all the other stations and arranged so as to trip the car hook on every car that passes having its selective finger at the proper height to engage with it. The bags, when dropped from the cars, are received on suitable chutes from which they slide to the floor or to tables. Just before the cars complete their circuit and reach the sending station again they pass a resetting cam, which returns the selective finger to the neutral position, ready to be set again at the sending station.

As the cars are permanently attached to the driving cable, a rather novel cable drive has been devised, giving a powerful pull and operating on a straight portion of the cable without requiring the introduction of grooved driving sheaves. In this driving device the cable is driven by a series of gripping jaws in pairs attached to an endless chain moving parallel to the cable, and driven by sprocket wheels. Each pair of jaws is connected by springs, thus giving a uniform pressure on the cable.

At the point when the jaws begin to leave the cable at the driving sprocket, a cam is located so as to open the gripping jaws and allow them to leave the cable and pass around the sprocket wheel and return again to the point of commencement, where another cam opens the jaws so as to allow them to grip the cable again. This device makes a very satisfactory arrangement, as it can be placed at any point of the line where there is a straight section of cable. The cars pass this drive without any trouble, and it does not require the addition of a number of driving sheave pulleys around which all of the cars would have to pass. With lines of any considerable length, it would not be possible to get sufficient driving power from a single-grooved driving sheave with 180 deg. arc of contact, and several driven sheaves around which the cable and the attached cars must pass in succession would introduce several objectionable complications.

BOOK CARRIER.—Among the carriers with individual cars, each car having its moveable selective finger, the most interesting perhaps is the so-called Factory Service Carrier. This was originally developed for transporting books in large libraries between stations located in the book stacks and the delivery desk, but it proved to be very well adapted for distributing small manufactured parts and tools from one part of a factory to another.

The cars are permanently attached to a wire cable at intervals depending upon the amount of traffic to be accommodated. The track upon which the car wheels run is of $\frac{3}{4}$ in. round cold rolled steel and the cars are of the finger bottom type so that the car can pick up its load or drop its load by passing between a similar set of fingers forming the stations. A system of this type is shown in Fig. 8 with car en route.

The car body is mounted upon a truck and arranged to swivel so as to keep the car body in a horizontal

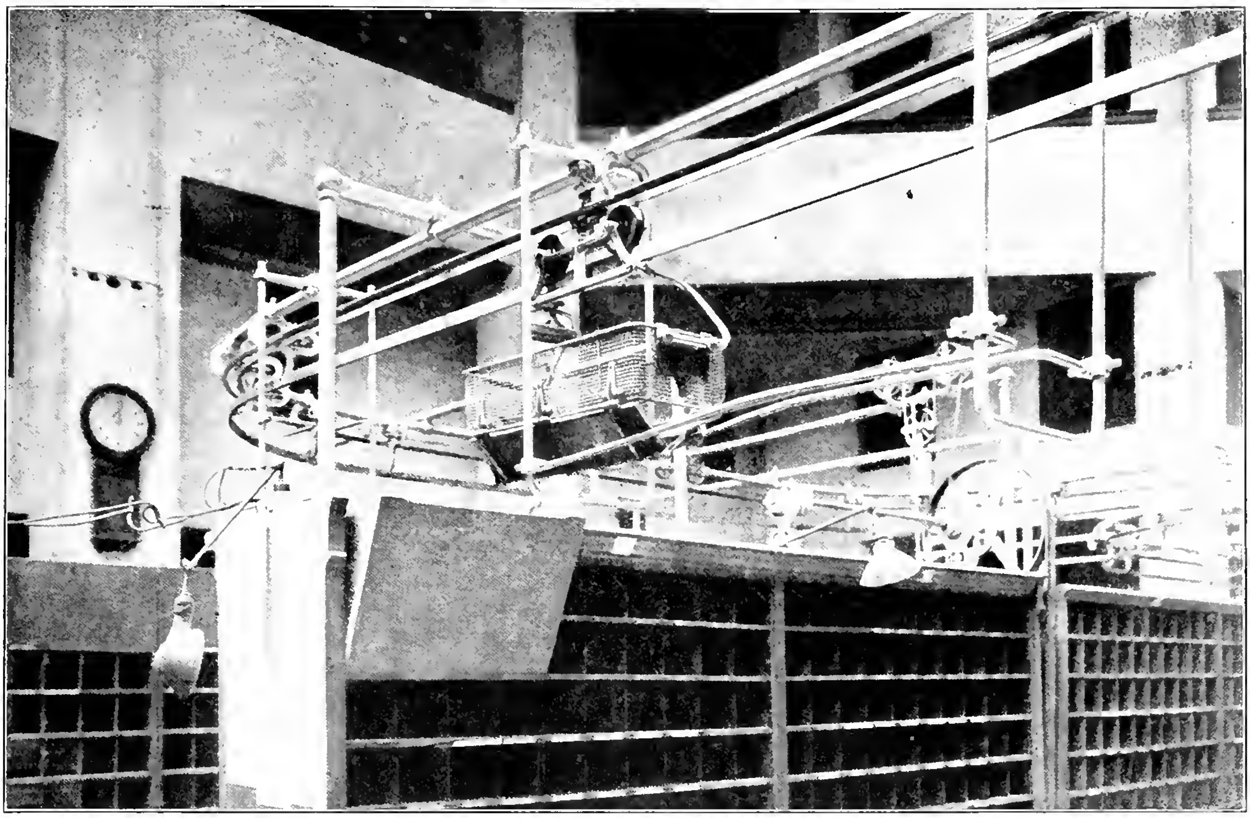

FIG. 12 A SWEEP-OFF CARRIER JUST LEAVING A STATION AND CLOSING BOTTOM DOORS

position when the car is traveling on vertical track as well as when the track is horizontal. This type of carrier can pass from floor to floor vertically and can make horizontal turns at any angle so as to reach any required position or avoid obstructions, as shown in Fig. 10.

In this system we have again the moveable selective finger upon the car to determine, by its position, the station at which the car will deliver its load; and this selective finger is moved by mechanism at the loading station under control of the operator. The cars in all cases pick up their loads when passing upward through the sending station fingers and drop their loads upon the receiving station fingers when passing downward through these station fingers.

As the cars are continually passing the sending stations, it is obvious that the loaded sending station fingers must be kept out of the path of loaded cars but must be advanced into the path of the first approaching empty car so that the load can be picked up and carried to its proper destination.

To carry out this condition, the sending station fingers are mounted upon a wheeled truck operating upon horizontal rails. This finger truck is normally held back by a weight working within a dash pot tube. When the operator has placed a load upon the sending fingers he moves a lever to a numbered position corresponding to the station to which the load is to be sent and then depresses a lever, which compresses a spring and stores up sufficient energy to move the sending fingers forward when the next empty car arrives.

Upon the approach of an empty car the catch holding the station fingers back will be tripped and the fingers with their load will move forward into the path of the car. The car then picks up the load and while passing the station has its selective finger moved to the position corresponding to the delivery station. After the car has left the sending station, the catch holding the station in forward position is unlocked by the car and the sending fingers are drawn back by the counterweight out of the path of succeeding cars.

While the loading fingers are held back, awaiting the approach of an empty car, a loaded car will not trip the station catch because this catch is tripped by a lever arm on the car having two positions, one for an empty car and one for a loaded car, and the lever when in the loaded car position will not unlock the station catch. The receiving station fingers are hinged at the back end so that they are normally swung up out of the way of passing cars, but an approaching loaded car, with its selective finger set for a station, will operate a lever and throw down the station fingers so as to remove the load from the car.

As these station fingers drop only to an inclination of about 20 deg., the load will slide down and away from the fingers to an inclined shelf, from which the

loads can be removed by hand. After the car has passed down below the receiving station it operates a lever that swings the receiving station fingers up and out of the way of succeeding cars until the approach of another car, which has its selective finger set for this station.

This type of carrier is driven either by a grooved sheave wheel or, for a long line, by a grip chain drive as described for the bag carrier. This carrier has been developed with a car as large as 12 in. x 17 in. to take loads of 15 to 20 lb., and these loads are generally handled in flat trays or baskets unless the loads consist of letters or papers that can be handled in envelopes or file wrappers.

SWEEP-OFF CARRIER.—Another type of carrier known as a Sweep-off Carrier has been developed more especially as a collecting carrier for collecting letters, orders, or other papers from a considerable number of stations and delivering them to a limited number of receiving stations located somewhere on the circuit of the line.

In this conveyor the load is carried in a basket supported from a two-wheeled car running on a single rail with guide rails below to keep the basket from swaying. The material to be sent is laid upon a horizontal shelf located just above the path of the basket and this material is swept into the basket by a brush attached to the car and moving with it. A considerable number of stations, therefore, can be served by a single car.

The basket of this carrier has a hinged bottom and will drop its load into a hopper when the car bottom is unlocked at the delivery station. It is possible to make this carrier selective by furnishing a number of separate shelves at the several sending stations. The shelves in this case are normally below the path of the car and are brought up to the sweep-off position when the proper car arrives and trips the holding down catch.

The cars are provided with permanent selective devices, which are operated by the receiving stations so as to trip the car doors on the basket when it arrives at its own station, but which are arranged to pass all the other cars which deliver at other stations. This type of carrier has been used very largely in Post Offices to handle misdirected letters from the various sorting cases to some central point where proper addresses can be supplied or where illegible addresses can be deciphered.

Promptness in handling such letters will generally prevent the letters from being held over to the next delivery and sometimes will prevent them from being held over to the next day. In large Post Offices this type of carrier is often used to collect the Special Delivery letters from the facing tables and from the opening tables where the railroad mail is received and to carry these specials to the special delivery division.

PNEUMATIC CONVEYORS

By F. B. WILLIAMS, BOSTON, MASS.

Member of the Society

The first successful pneumatic tube system was put in operation previous to 1858 in London, England, with a $1\frac{1}{2}$ in. tube 650 ft. long. In 1858, this was extended with $2\frac{1}{2}$ in. tubes. From then on the system has grown rapidly and London has now many miles of despatch tubes. The usefulness of this system has also been extended in the large cities of England and Germany. The transmission of telegraph messages by pneumatic tubes commenced in 1865. Also it was at about this time that pneumatic tubes were first used for transmission purposes in this country, John Wanamaker's store in Philadelphia having probably had the first installation.

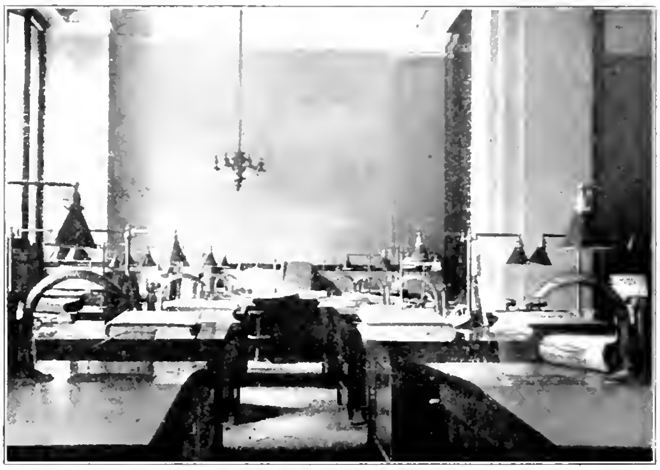

FIG. 1 VIEW IN A MODERN OFFICE WITH PNEUMATIC TUBE CONNECTION TO EACH DESK

There are three systems in general use, known as the vacuum, the pressure, and the vacuum-pressure systems. Each of these has very distinct advantages when considered from the standpoint of the service required and other determining conditions.

The vacuum system in its simplest form, omitting the power plant, consists of two stations, one called the central station and the other the out-station. As seen at the central station there is a sending and a receiving tube and these two tubes extend to the out-station. The receiving tube at the central station is connected to the suction drum, and as the two tubes are connected at the out-station, they form one air circuit.

A carrier placed in the sending tube at the central station is sucked to the out-station and there discharged by means of a suitable terminal. The air is there by-passed to the other tube, in which it returns to the central station and is drawn into the suction drum. A carrier placed in what is the sending tube at the out-station is sucked to the central desk and

there discharged, while the air is by-passed to the suction drum. In this way communication between the two stations is continuous; that is, carriers can be sent from each station to the other at the same instant—a very desirable feature where the service is heavy, as in a department store.

Vacuum terminals are simpler than the terminals for other systems and the method of operation by exhausting the air is more economical so far as the expenditure of power is concerned. But the working pressure is limited to something less than 14 lb. and there might be conditions which would make that insufficient.

The pressure system is just the reverse of the vacuum system, the carriers being pushed or forced by pressure instead of being sucked or pulled to their destination. Of course, theoretically, the operation of the two systems is similar in that the carriers are propelled by the greater pressure behind than in front of them. In the vacuum system the power is applied in front of the carrier, but in the pressure system it is applied behind the carrier.

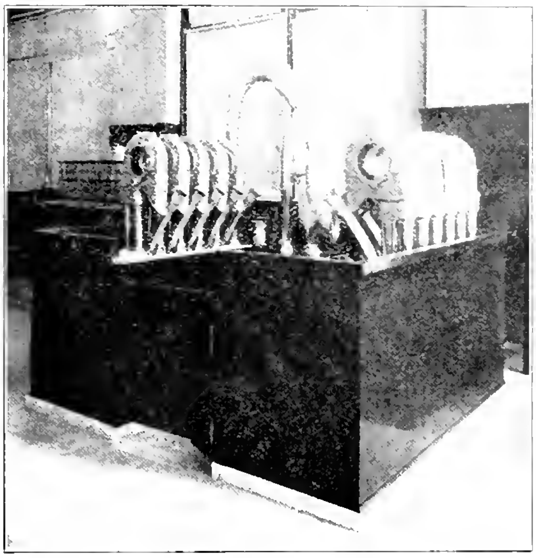

Fig. 2 A Terminal for a Vacuum-Pressure Tube System

Pressure systems are used in carrying the U. S. mail in many of the larger cities in this country and two of the several reasons why pressure is used instead of vacuum, are first, that with the pressure system, small leaks are not objectionable save that they are a direct loss of power, while with the vacuum system, a leak underground would be disastrous to the working of the system and also the possible entrance of moisture might cause damage to the contents of the carriers; second, in case of a carrier being blocked in the tube, the pressure can be reversed and raised and the carrier often blown out, while with the vacuum system the greatest vacuum possible might be entirely inadequate for this purpose.

Pneumatic tubes on the pressure system now provide direct connection to 46 United States Post Offices, which offices, according to the most recent Post Office statistics, serve a dependent population of 5,881,000 people. In these pneumatic tube Post Offices are employed 6,120 clerks and 3,131 letter carriers, and through the tubes are weekly carried 137,295,000 pieces of mail matter. Mail for Post Offices beyond the pneumatic tube districts is also carried as far as possible by tubes and then transferred to wagons. These statistics do not include the City of Philadelphia or the Brooklyn General Post Office. Each one of these Post Offices, because of its pneumatic tube connection, gives to its surrounding population the same service that is given from the main office of its city. In other words, the pneumatic tubes, since they are practically instantaneous, make the sub-stations with which they are connected a part of the main office of the city. It is interesting to note that, assuming the above amount of mail matter to be carried by the tubes for 52 weeks a year, the cost of carrying by pneumatic tubes is at the rate of ninety-two pieces mail matter for one cent, or approximately fifty-four cents per hundred pounds.

The vacuum-pressure system is used where the service is lighter. In this system the carriers are drawn to the central station by vacuum and blown back to the out-stations by pressure.

Here might be mentioned the single-tube pressure system of the Lamson-Miles type, which has but one tube between the two points to be connected. This tube is fitted with a combined despatching and receiving terminal at each end, and the compressed air is carried by small iron pipes to the terminals at the ends of the tubes. A compressor and storage tanks supply and maintain the power for operating the tubes. When idle the tubes are normally open to the atmosphere and are often used as speaking tubes. The use of a single tube saves room in passageways and walls of buildings, frequently a matter of great importance.

When a carrier is to be transmitted, air pressure is introduced into the tube behind the carrier from the storage tanks, in which pressure is maintained by an automatic regulator, that controls the starting and stopping of the compressor. The compressor automatically starts when the pressure drops below a certain point and stops when it has produced the normal working pressure of the system. The air supply pipe is much smaller in area than the transit tube and consequently while the carrier is on its course the air under pressure from the supply pipe expands in the tube. Hence if a carrier tends to foul in a bend or other part of the tube, it offers a resistance and the air pressure behind it immediately makes up to the pressure carried in the supply pipes and thus the carrier is automatically relieved and pushed along.

A combined receiving and despatching terminal is attached to the ends of each tube, and to these terminals are also connected the supply pipes so that

the air pressure can be admitted to the tube at each end and carriers can, therefore, be despatched alternately from either end of the same tube. As a transmission takes but a few seconds, no practical inconvenience is experienced by using one tube for transmission in opposite directions. In answer to the question as to what will prevent carriers from being despatched from both ends of a tube at the same time, it should be stated that this does not happen because the tube is normally open at both ends and when a carrier starts from one end, the free air in the tube is forced ahead of the carrier and out at the other end; thus a carrier cannot be inserted at what is temporarily the receiving end until the traveling carrier is expelled, because the outward rush of air makes it impossible.

The operation of the combined receiving and despatching terminal is as follows: After a carrier has been inserted for transmission, a gate or cover normally open, is closed behind it, which closing of the cover automatically locks it in place and at the same time opens an air valve, permitting an inrush of compressed air behind the carrier. The compressed air expands and pushes the carrier at increasing speed to the discharge end of the tube, where it is deflected by a chute into a suitable receptacle. A simple device cuts off the air pressure at the despatching end, and at the same time the closed gate or cover at the sending end is unlocked and the tube is again thrown open to the atmosphere. All these operations are accomplished by the back pressure of the air behind the carrier in transit without the use of electric or other connections.

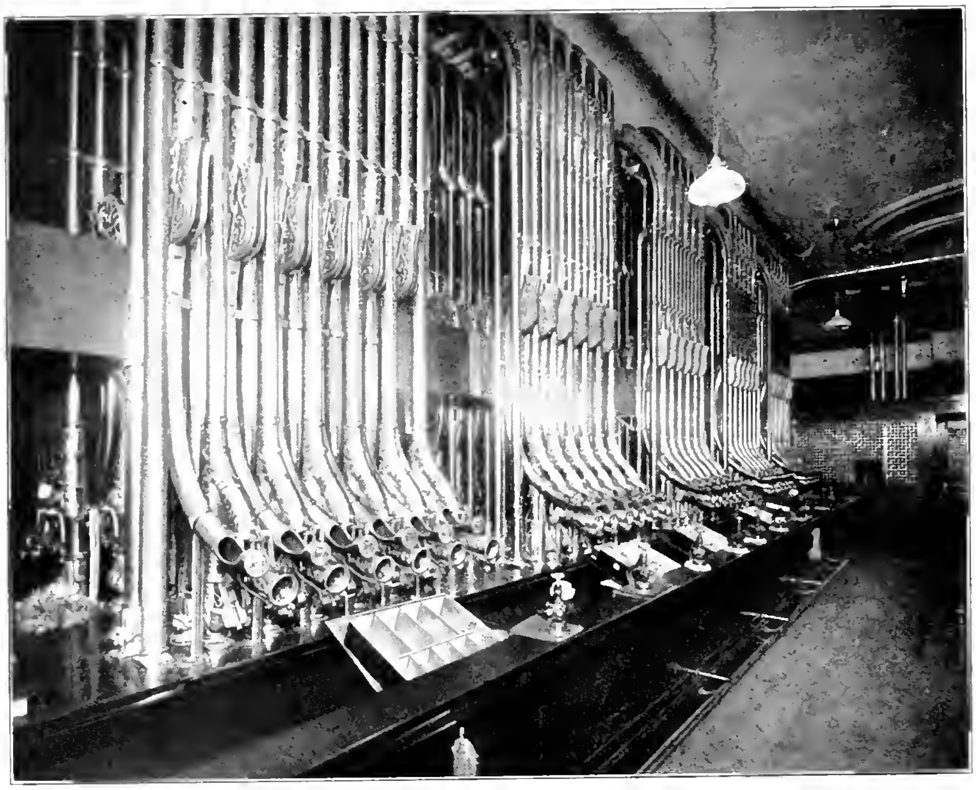

Fig. 3 A Large Central Desk for a Department Store System

The tubes used for the transmission of carriers are of kalameined steel, brass, or aluminum. The sizes mostly in use are $2\frac{1}{4}$ in. and 3 in. outside diameter. Also 4 in. tubes and 3 by 6 in. oval tubes are largely used where the material to be transmitted is bulkier. The bends are made of brass, and are formed by cutting to a length according to the radius of bend desired, filling with water and while under hydraulic pressure, bending around a form; the operation takes but a very few moments and a perfect bend is formed, with the section absolutely circular.

Positive rotary blowers are used in the majority of the plants installed. This type can be used either as a pressure blower or as an exhauster, and is more economical than a compressor when operating against pressures less than 7 lb. per sq. in. The style of blower used consists of a casing in which two impellers revolve in opposite directions, each impeller being of a double lobe section symmetrical with its shaft and the two impellers so set that the lobe of one fits into the recess of the other. The impellers work as close as possible to the casing so as to prevent loss through leakage, and to keep them at their proper relative speeds, one shaft is driven by the other through a pair of gears. If the system is of the vacuum type the inlet side of the blower is connected to the galvanized iron suction drum in the central station, if of the pressure type, the outlet side is piped to the central station, and if of the vacuum-pressure type, both inlet and outlet are piped

to separate drums in the central station. The blowers are usually driven by electric motors, although occasionally they are directly connected to steam engines.

With many of the vacuum and pressure systems a power saving device is used, as in a system of, say 40 out-stations, it is safe to say that the greatest number that might be in use at one time is 28, and power must be supplied for 28 lines. Ordinarily but 4 or 5 are in constant use. By using a variable speed motor, of say four to one range, the blower can be made to supply power for, at its lowest speed, 3 lines, but as demands for more service are made from time to time during the day the motor will speed up until the maximum of 28 is being taken care of.

When the power control system is used on vacuum lines, a vacuum of, for instance, 16 oz. is maintained

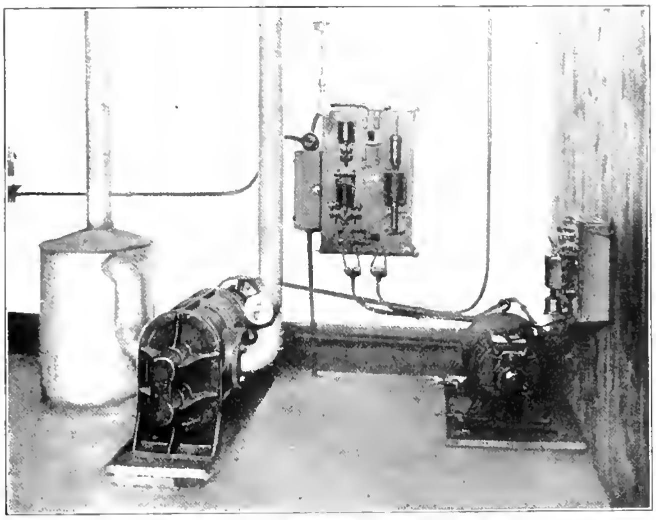

Fig. 4 View of a Blower Plant for a Small System, showing Automatic Control Board and Muffler

in the suction drum at all times irrespective of the number of lines in service. This constant vacuum is maintained by connecting the suction drum to the upper part of a cylinder in which is a weighted piston, that remains balanced and stationary as long as the vacuum above it equals 16 oz.; but should the vacuum drop, by opening of a tube for the transmission of a carrier, the piston slowly drops and at the same time turns the field rheostat of the motor so as to speed the blower up to maintain the 16 oz. vacuum. Should a greater vacuum momentarily exist a relief valve operates to reduce it to the proper point.

When the vacuum in any one of the lines is broken by the insertion of a carrier, a device at the end of each air circuit, called a power control device, automatically keeps the line open long enough for the carrier to reach its destination and then " times off," and the line comes to rest and so remains until the next carrier is inserted. It is not necessary to wait until one carrier has reached its destination before inserting the next; the vacuum in the line will take care of several carriers, and, except in the case of a very long line, it would be almost an impossibility to overload an air circuit because the carriers travel at such a high rate of speed that they would begin to deliver at the other end before the critical load was reached. And as in actual practice, the carriers must be loaded with letters, messages or cash, there must be an appreciable interval of time between each transmission of a carrier, and this prevents any one line from being overloaded. This power-saving device is of the vented cylinder and piston type and is very flexible as it can be adjusted for varying lengths of lines. It can be set to " time " anywhere from $1\frac{1}{2}$ seconds to 2 minutes to accommodate any length of line.

From an engineering stand-point, the best system is one that uses power only when a carrier is in transit and is known as the start and timing-stop system. This system is operated by means of a special switchboard, on which an electric circuit is closed by the insertion of a carrier in the terminal for transmission, and that throws in the main power circuit, causing the motor-blower unit to automatically start up and supply the necessary vacuum or pressure, as the case may be, and it does not stop until the carrier reaches its destination. If several carriers are sent, even from remote parts of the system, the power is supplied until the last carrier is delivered.

The latest improvement is the " power-saving start and timing-stop system," which is similar to the previous system, but goes one step farther and supplies power according to the number of lines in service. If one is used, power for one is supplied; if half a dozen, the power unit speeds up to supply the proper power for those six lines and then comes to a stop when the last carrier is delivered. This is as it should be; in all but the largest systems, there are a great many times when no carriers are in transit, and then there are times when there may be several, possibly up to the capacity of the system, dispatched at almost the same time. This system uses only as much power as is required to transmit the carriers and shows a very great saving over all other systems.

The terminals used are of brass and bronze construction, except in some of the largest sizes where iron is occasionally used. Most of the terminals used on the larger vacuum tubes are of the double-door type, in which the carrier passes through two valves before it delivers. This for two reasons: One is that the noise is eliminated, and the other is that the momentum of the carrier is lessened. When a carrier passes from the tube into the terminal it passes through the first valve into a chamber where the air pressure is slightly below atmospheric; its momentum, checked by its passage through the first valve, carries it through the second valve into the atmosphere and to the receiving basket. The noise of the vacuum terminals was one of the principal objections to that system as applied to

large tubes, but since the double-door terminal has been perfected there is no annoyance on that score.

The carriers are of leather except those used in department stores, which are of metal with felt heads. The leather carriers are made in various lengths with hard felt heads and are of both closed and open types. The lengths of carriers are determined by two factors, the requirements of the service and the radius of the bends. A carrier 8 in. long, for a 3 in. pneumatic tube, requires bends of $2\frac{1}{2}$ ft. radius, and a carrier 10 in. long requires bends of $3\frac{1}{2}$ ft. radius.

It is often a serious undertaking to lay out the tubes and bends for long carriers so that they will not be unsightly or interfere with the design of the building in which they are located. The modern office building has usually a chase or riser flue that is available for the risers to the various floors, but in some of the reinforced concrete buildings and those of the mushroom type of construction, the difficulties of installation are numerous.

Pneumatic tube systems are used principally for the transmission of cash, mail, or messages of an interdepartmental character. Occasionally they are used for the carrying of other material, as in the Winchester works in New Haven, where powder is delivered to the loading machines by pneumatic tubes. The Eastman Kodak Company has an extensive system of tubes which perform a service that would be almost impossible to duplicate by any other means. Their stocks of films, plates and bromide and other papers are kept in rooms dimly illuminated by means of specially colored electric lights, and these rooms are so dark that a person going in from the outside would be almost helpless. The pneumatic tube service is effective in these rooms, whereas it is easy to see that a messenger service would be not only very slow in comparison, but very greatly handicapped on account of the illumination.

One of the essential routine requirements of a factory, large or small, is an equipment for handling mail, instructions, orders, and blueprints rapidly. Unless the method of distributing the mail is effective, delays and confusion always result. This is particularly true in the big factories where often more mail is handled daily than passes through many a small city post office. But the methods adopted by these large establishments are applicable as well in the small plant, for the complete system for handling the mail is generally built up of several units, any one of which can be advantageously adopted in the smaller factory. Those reasons of economy which bring refinement in the large plant are just as effective in the smaller establishment where their importance is often overlooked. Pneumatic tubes bring remote buildings side by side for business purposes.

An interesting industrial application of pneumatic dispatch tubes has recently been made to a modern "hump yard" freight terminal which due to the peculiar governing conditions, has resulted in an unusual economy. The saving due to this installation, at a total

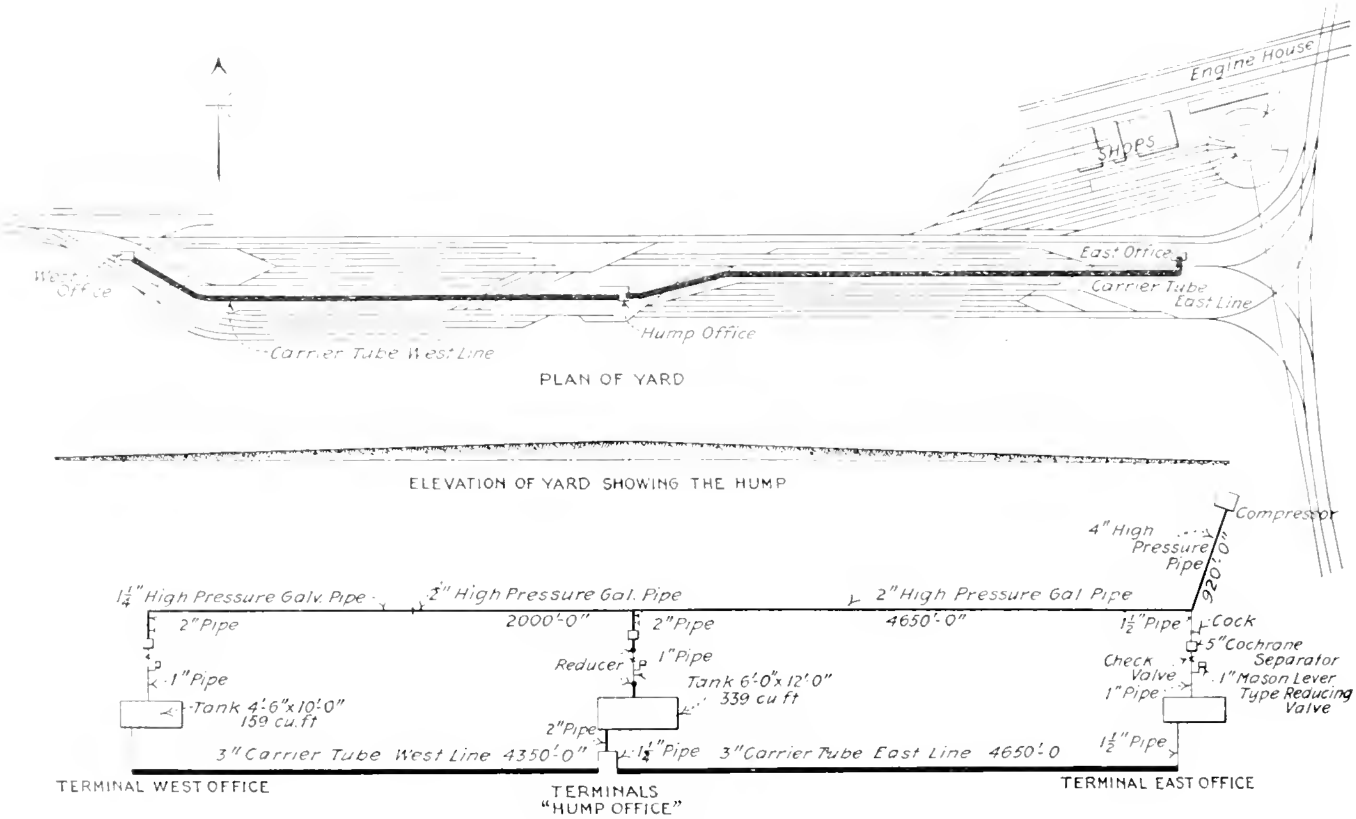

Fig. 5 Arrangement of the "Hump" Freight Yard Layout and Details of Tube System

investment of less than $10,000, amounts to an actual cash saving of at least $500 per day, while at the same time an increased efficiency of service is gained, the value of which is incalculable but of utmost importance (Figs. 5 and 6).

This yard is located at Gibson (near Hammond), Indiana, 23 miles southeast of Chicago on the Chicago, Indiana & Southern Railroad, being the Chicago freight terminal of the New York Central lines. The function of this yard is to facilitate the distribution of cars from incoming trains for prompt delivery to connecting roads, and conversely, to assemble into outgoing trains the cars received for forwarding. This

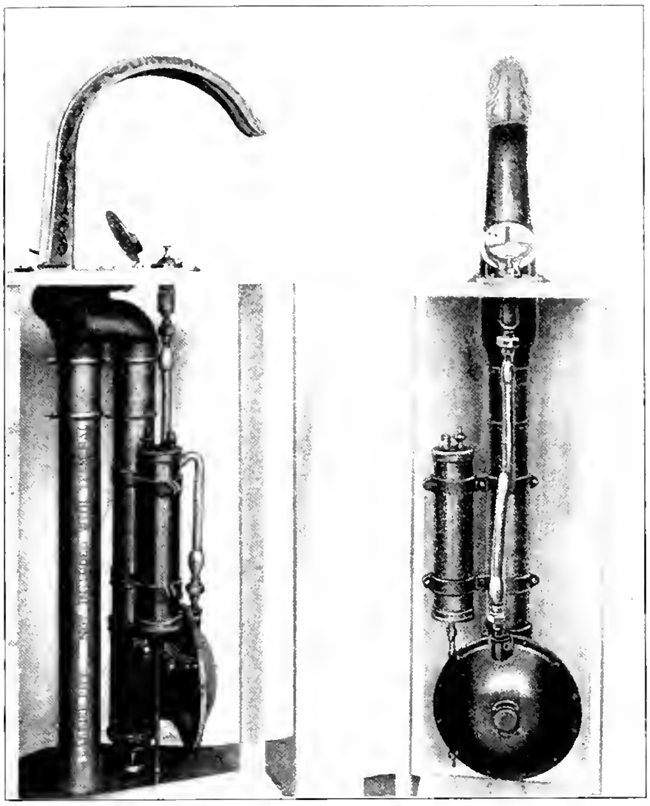

FIG. 6 TERMINAL USED ON THE "HUMP" YARD SYSTEM

is accomplished in the following manner: The yard is laid out as an East yard and a West yard, each practically a duplicate of the other, and consisting of series of adjoining tracks with connecting ladder tracks at both ends. These lead respectively east and west from an artificial elevation in the level of the yard between them, and a car upon being pushed up this elevation by a locomotive will, after getting over the peak or highest point, run down on the other side by gravity where it may be switched from the ladder track into the yard tracks at will.

To illustrate, assume an incoming train to consist of 50 cars destined for, say, 20 different connections, the first two for A, the next one for B, the next three for C, the next two for A, and so on; the engine which has brought the train in is disconnected therefrom and a switch engine pushes it up the hump until the first two cars pass over the peak of the grade and run down on the other side, where they are switched say to track No. 1, followed immediately by the third car, which is switched to track No. 2, this in turn by the next three cars, which together are switched to track No. 3, the next two cars to track No. 1, and so on till all cars in the train have been distributed and thus reassembled directly into new trains with practically a continuous and uninterrupted movement of cars in the same direction all the time.

The incoming train brings the forwarding instructions from which orders covering proper distribution of cars are made out by the clerical force at the main yard office adjoining the Hump. In order therefore to insure quick handling of trains, it becomes imperative to have forwarding instructions delivered to the office and the orders in turn delivered to the train and yard crews in the shortest possible time. This is done through the Yardmaster's offices, each of which is nearly a mile from the main "Hump" office in opposite directions, and as the movement of trains is directly dependent upon these orders, it follows that any delay in the transmission means an equal delay in the despatching of trains, with a direct loss of an amount equal to cost of train crews. Hence the importance of the time element is at once apparent, but the extent of its importance will be better appreciated when it is understood that the railroad management figures the cost of a train crew at $5 per hour and that a total of from 150 to 200 trains are handled at this yard every 24 hours. Messenger boys were formerly used, and even at best the time for transmission was very considerable owing to the distance to be covered, the character of roadway and the natural unreliability of such service, while in inclement weather the business was well nigh paralyzed.

Since the installation of the pneumatic tube system by use of which it takes less than three minutes to convey messages between the Yardmaster's offices and the "Hump" office, and which have proven reliable in all kinds of weather, there has been saved one-half hour to an hour (an average of ¾ hr.) in the time of each train crew from which the direct money saving figures out as follows:

Cost of train crew, ¾ hr. @ $5 per hour. $3.75
Trains despatched in 24 hrs. (150 to 200, or a mean of 175).......... 175 Trains
Hence direct money saving per 24 hrs. is 5 (dollars) x ¾ (hour) x 175 (trains per day) equals $656.25...$656.25

Thus the figure of $500 per day, as given above, is a very conservative statement.

The system is of the straight high pressure pneumatic type, with diaphragm latch terminal and supplementary time-off device, there being two single lines of 3 in. kalameined steel tubing, one running from the "Hump" office to the East Yardmaster's office, a

distance of 4650 ft., and the other running from the "Hump" office to West Yardmaster's office, a distance of 1350 ft. The tubing is laid from 3 to 4 ft. underground (frost line is about $4\frac{1}{2}$ ft. down), joints being made with sleeves of a rust-proof composition called "Toncan Metal," and the whole is heavily coated with asphaltum paint. The terminals are of the up-discharge type with vent-actuated pressure timing valve and special long timing control.

Both ends of the tubes are alike and are normally open, with no air flowing. In sending, a carrier is inserted in a terminal, the clapper closed and air then admitted behind the carrier by pressing a button, which actuates the automatic control device, by which air is delivered from a low pressure storage tank for a pre-determined period, sufficient to insure arrival of carrier at other end of tube. Air is supplied to the storage tanks from the regular railroad service for operating switches, signals, etc., at a pressure of 90 to 110 lb. at the compressor. This is located in a shop some 950 ft. from East Yardmaster's office and there is a loss in pressure of about 20 lb. in transmission. There are three storage tanks, one at the East Yardmaster's office, one at the Hump office and the third at West Yardmaster's office. The air is brought underground from the compressor to the East tank, with branches to the Hump and West tanks, to each of which it is connected through a 5 in. Cochrane oil and water separator, a 1 in. check valve and a 1 in. Mason lever type reducing valve, that keeps the air at 11 to 15 lb. pressure in the tank, depending upon conditions. A $1\frac{1}{2}$ in. or $1\frac{1}{4}$ in. pipe leads from the tank to the pressure timing valve on the 3 in. carrier tube, in each case giving a pressure in the tube behind the carrier of from 6 to 10 lb. The tank at the Hump office, about 5570 ft. from compressor, is supplied by 4650 ft. of 2-in. iron pipe, and connection to the tank is made in the order named through a 2-in. cock, a 5-in. Cochrane oil and water separator, a 1-in. check valve, a 1-in. mason lever type reducing valve, and a 2-in. pipe. The pressures are approximately the same as on the East tank.

No extra help is employed in connection with the tube system, the carriers being handled by the clerks, who make out the orders. The total number of carriers transmitted over the whole system for the 24 hours ending at 1 p.m., May 17, 1913, was by actual count 220, which is said to be about half the normal average during the busy winter season. The cost of maintenance, including all labor and material for the entire system of tubes, supply pipes, etc., for the three months of January, February and March, 1913, amounted to $17.92, which included an abnormal expense for clearing out the high pressure supply pipes, necessitated by their having been frozen. (It will be noted above that the pipes were not laid below frost line.) This monthly average of $5.97 is therefore high and a more nearly correct figure would be about $3 per month.

MACHINERY FOR HANDLING SMALL PACKAGES

By S. L. Haines,[1] Boston, Mass.

Non-Member

The above subject covers a very wide field, and involves many classes of conveyor machinery, but the intention is here to present an illustration of one of the latest developments in this line, namely, a novel method of handling magazines, the Saturday Evening Post and the Ladies' Home Journal, in the publishing house of the Curtis Publishing Company, Philadelphia. The same types of machinery, modified to suit conditions, may of course be used for the handling of light boxes, small packages, etc. In connection with the above examples I will also show the manner in which the mail bags, filled with the above magazines, are handled, by means of the various types of elevators, lowerers, conveyors, etc.

The magazine handling equipment consists in general of two duplicate lowering machines for the Home Journal, and two duplicate lowering machines for the Saturday Evening Post, with a belt conveyor distributing system in the delivery room for each pair of conveyors. Fig. 1 shows the arrangement of the machines as actually installed. Two of the lowerers are vertical machines about 73 ft. center to center of head and foot shafts and the other two have also a horizontal run of about 50 ft. Each lowering machine has two steel roller chains running over sprocket wheels as indicated, and have corner hung steel trays suspended between them and spaced 5 ft. apart. The trays have two sides, a back, and bottoms made with two slots running from front to back so that loading and unloading fingers can extend well back into them.

The loading is accomplished by automatic loaders at each floor. The magazines come from the trimming machines in stacks $3\frac{1}{2}$ in. high and two of these stacks are placed together, one with the backs one way and the other with the backs the opposite way, making a 7 in. stack. These 7 in. stacks are then moved to the loading points where an attendant places them, one at a time, on the loading fingers, which, when at rest, are just outside the casings of the lowerers. The loaders are set opposite the ascending line of trays and each one is operated by means of a small auxiliary chain with a lug, or attachment, which engages with another lug on the main chain, just before a tray passes, thus working a crank and connecting rod mechanism that moves the fingers inward and directly over the slots in the tray. Each stack of magazines is then picked up by a tray, carried up and over the head sprockets and down to the automatic unloader in the delivery room.

In order that the loaders may operate only when

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magazines are placed on them, the lower shaft and sprocket of the auxiliary chain are arranged in such a manner that ordinarily they are back far enough so that the lugs will not engage and no movement of the loader takes place. It is part of the duty of the attendant, after placing a stack of magazines on a loader, to throw a lever which moves the lower shaft of the auxiliary chain forward into the engaging or operating position.

Further, it is obvious that with this system of loading, it would not be possible for a loaded tray to pass loading fingers in the forward position, since the slots in the tray bottom would be covered by the magazines. Since loading on the several floors at the same time was one of the requirements, it was necessary to make the loaders selective, that is arrange them so that they would pick out only empty trays. This was accomplished by arranging an arm, A, Fig. 1, at each loader so that it would pass through one of the slots of an empty tray but be thrown back by the magazines of a loaded tray and release a trigger which prevents the loader from operating.

The unloading is accomplished by having each descending tray deposit its load of magazines on two narrow moving belts which extend into the slots in the tray bottom, as at B, Fig. 1. These unloader belts, one of which is shown in Fig. 2, are located in the delivery room on the first floor, the ones from the two Post lowerers delivering to a single wide belt conveyor running between the mailing tables, and the ones from the Journal lowerers delivering first to a short belt conveyor and then to another belt conveyor at right angles and also running between the mailing tables.

At the present time the lowerers run up to the 5th floor with loading points on the 2nd, 3rd and 4th floors, but they have been built with the idea that they may some day be extended to the 8th floor. They are operated at a speed of 60 ft. per min., so that with the trays spaced 5 ft. apart this means a maximum of 12 trays per minute. A 7 in. stack includes thirty-six 92 page Posts or fifteen 124 page Journals, so that when handling magazines of this size each lowerer has a maximum capacity of 25,920 Posts or 10,800 Journals per hour.

The drive for the two lowerers, which is operated by one $7\frac{1}{2}$ h.p. electric motor, is arranged so that the trays will deliver their loads of magazines at the proper alternate intervals to avoid interference when they are delivered to the same belt conveyor in the delivery room. It is so arranged that a spare motor can be thrown in on short notice in case of trouble with the other motor. The two belt conveyor systems in

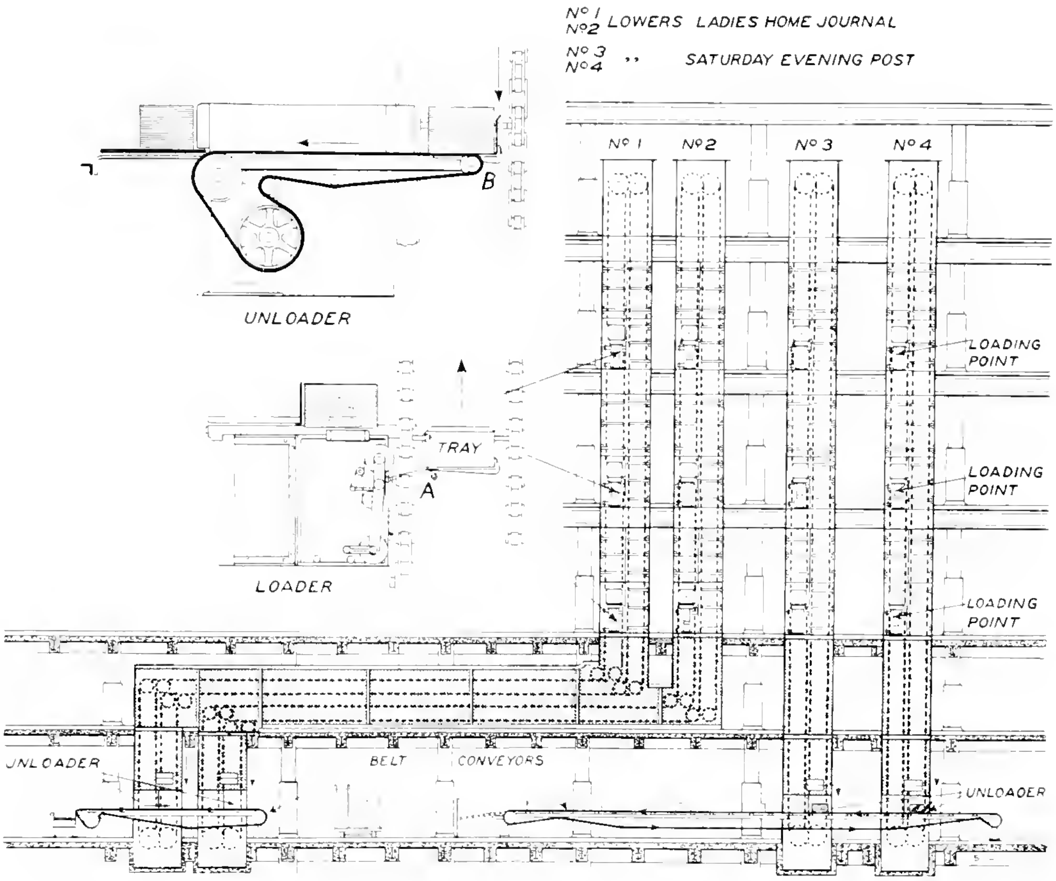


Fig. 1 Diagram showing Arrangement of a Large Installation of Magazine Handling Conveyors, with Details of Loaders and Unloaders

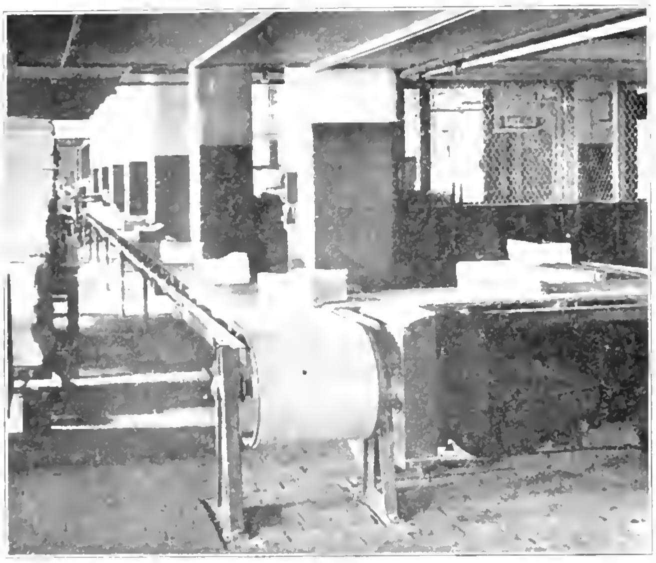


Fig. 2 View of one of the Unloading Belts in the Delivery Room

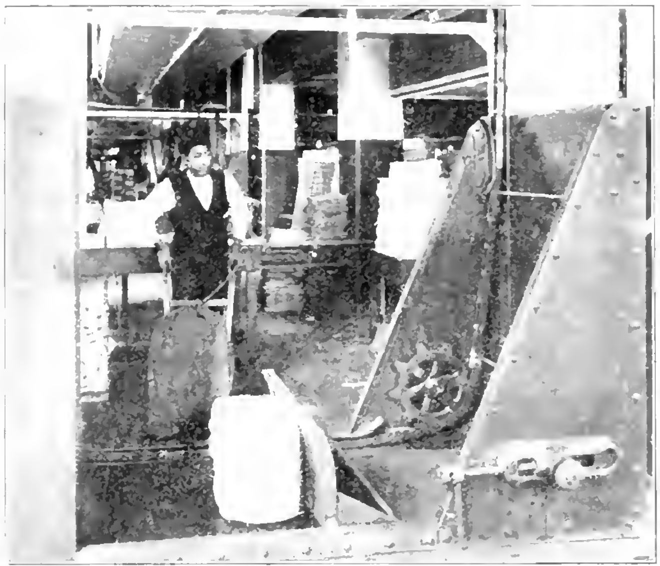
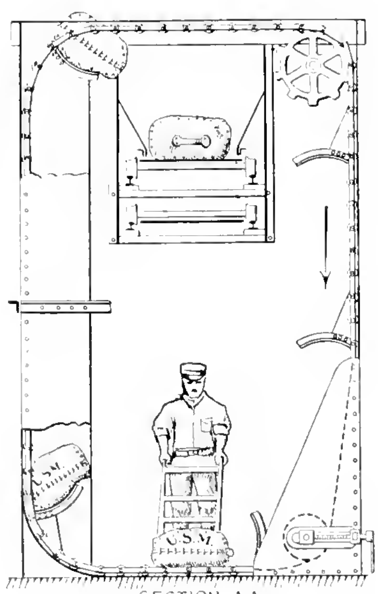


Fig. 3 View of one of the Mail Bag Elevators for raising Bags to the Horizontal Conveyor

the delivery room are each driven by a 1 h.p. motor.

The electric control system is arranged so that the machines can be started and stopped from any floor and each lowerer is equipped with counters at head and foot and on each loader, so that the number of stacks of magazines can be accurately counted and also that the counts from the different counters checked up to see that they tally and that none of them have been tampered with.

The mail bags are filled at the mailing tables in the delivery room, taken to the north end of the room and either stored on a mezzanine floor for a future shipment, or weighed and sent out at once. Since there are several hundred of these bags to be handled per hour, it would mean considerable labor and more or less confusion to truck them all the way through the room, besides which it is necessary to take part of them to the mezzanine floor. It was decided, therefore, to install three continuously moving chain and arm elevators, located at convenient points, and an overhead apron carrier, or moving platform, running to the north end of the room and delivering to the mezzanine floor. The attendant dumps the mail bags from his truck at the foot of an elevator, they are taken up and delivered to the apron conveyor, carried to the north end of the room and deposited on the mezzanine floor. Here a second man either places the bags in a certain compartment, according to their destination, or sends them down a chute to the weighers on the first floor.



SECTION A-A

These elevators, one of which is shown in Fig. 3, are of a special design arranged so as not to extend below the floor level and yet be easily loaded at the floor level. The chains are 6 in. pitch, steel bushed, steel roller chains and at intervals of $6\frac{1}{2}$ ft., there are arms consisting of two brackets attached to the chain with pin connections to allow of flexibility and having curved steel plates across the full width. The path of the chains is shown in Fig. 4. When an attendant dumps a mail bag on the steel plate just above the floor,

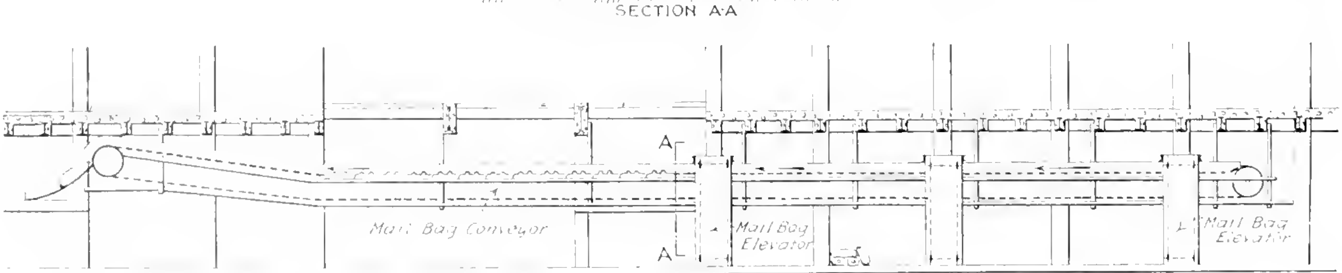


Fig. 4 Details of the Mail Bag Elevator and Arrangement of the Horizontal Bag Conveyor

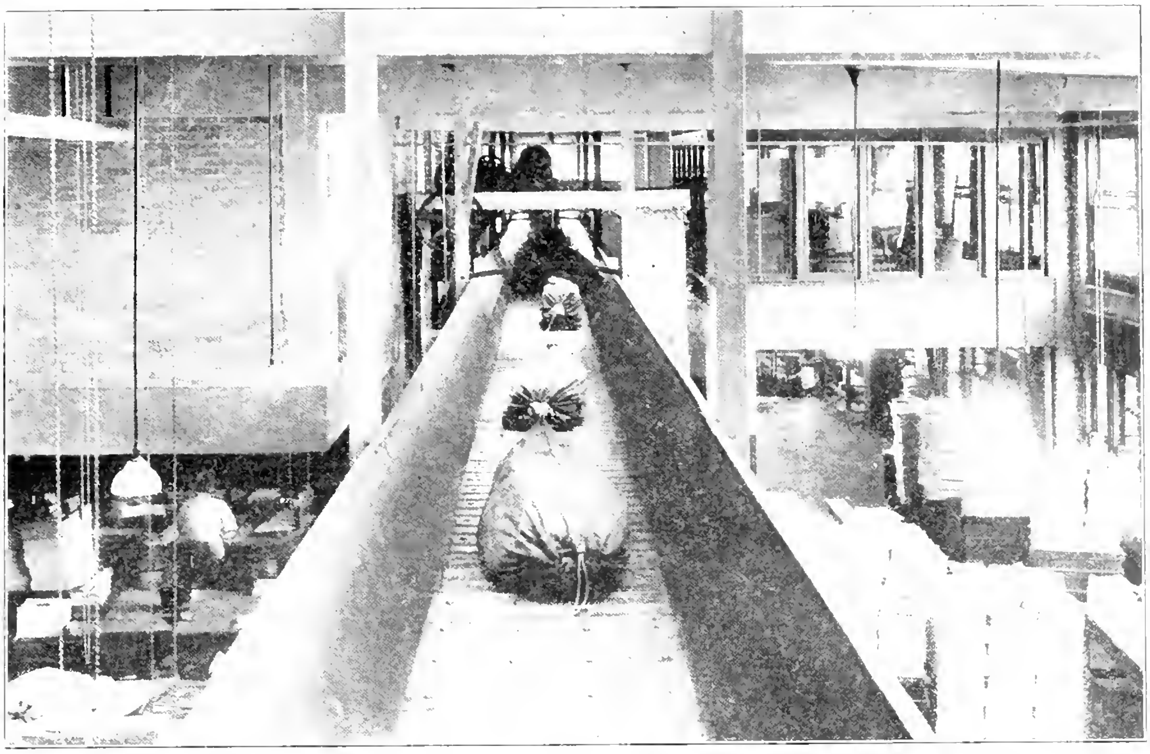


Fig. 5 View of the Horizontal Mail Bag Conveyor in Operation

an arm comes along and sweeps it up around the curve, carrying it up and discharging it at the upper turn so that it falls on the steel apron conveyor.

The apron conveyor, a view of which appears in Fig. 5, is made up with two 12 in. pitch, steel bushed, steel roller chains with corrugated steel slats attached to them so as to form a continuous apron 3 ft. wide. The mail bags ride along on the apron to the end of the

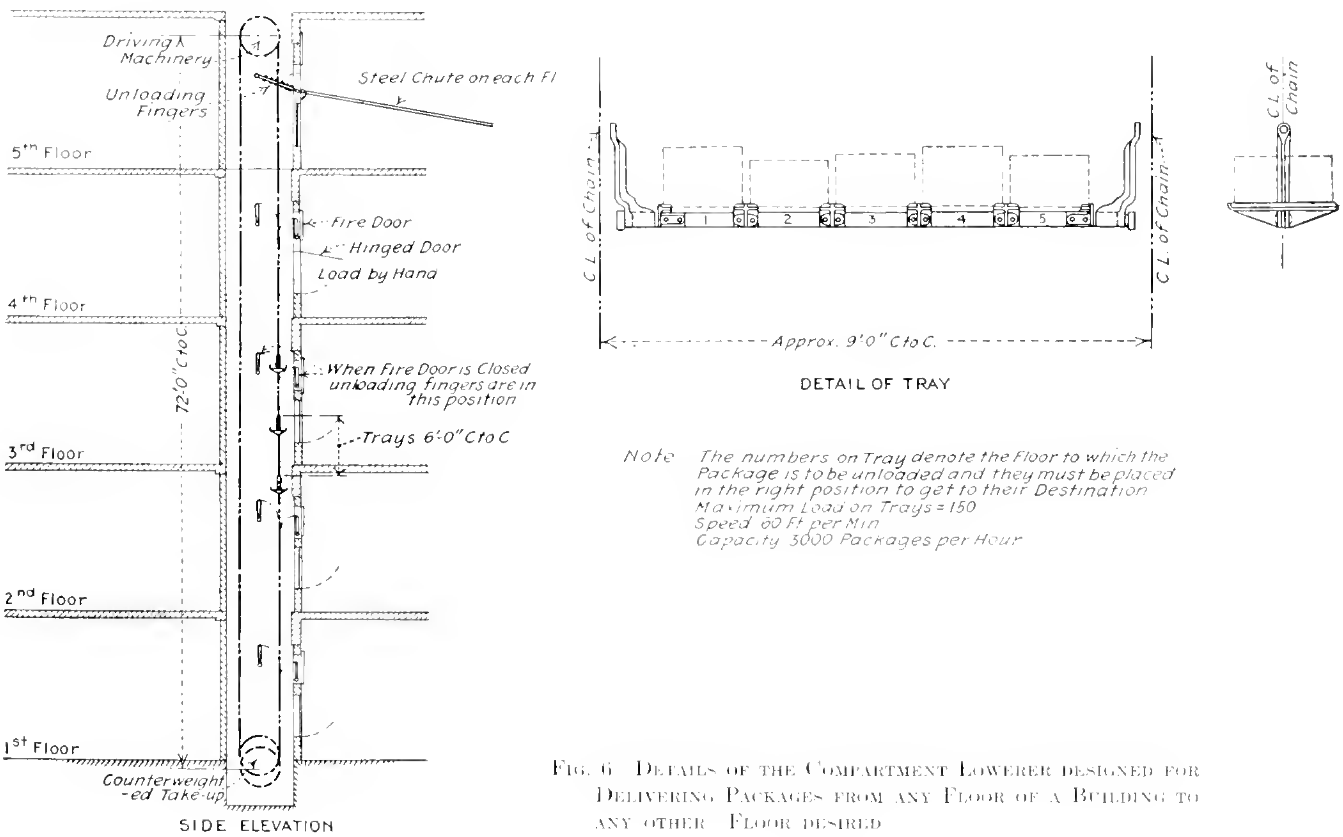


Fig. 6 Details of the Compartment Lowerer designed for Delivering Packages from any Floor of a Building to any other Floor desired

conveyor and fall off into a chute as the chains pass around the sprocket wheels.

The apron conveyor is 166 ft. long and operates at a speed of 80 ft. per min. It is driven by a 10 h.p. motor, and the speed reductions from this motor and also from the elevator motors are made by silent chain drives from the motors to the first counter shafts and then with cut gears.

Each elevator is driven by a 3 h.p. motor, and at a speed of 65-ft. per min., has a capacity of 600 mail bags per hour, the maximum weight of the bags being about 200 lb.

Fig. 6 shows a later type of elevator and lowerer, known as the compartment lowerer. It will be seen that the tray of this conveyor is made up of five compartments, and the building in which it is used is five stories high. The machine is used where boxes are loaded from various floors and it is the wish to unload at various floors. Each compartment has a number corresponding to a different floor. Material put on at any floor and assigned to the fourth floor, would of course be put in the fourth compartment, and at that point would be automatically discharged by the roller fingers as shown opposite the fire door openings. The speed is 60 ft. per min. and the capacity about 3000 packages per hour.

THE POWER PROBLEM IN THE ELECTROLYTIC DEPOSITION OF METALS

BY H. E. LONGWELL, PITTSBURGH, PA.

Member of the Society

THE meeting of the Society in New York on January 9, 1914, was a joint meeting with the American Institute of Electrical Engineers and the American Electrochemical Society, at which was held a symposium on the subject of Electrolytic Deposition of Metals. Lawrence Addicks, Mem.Am.Soc.M.E., representing the American Electrochemical Society, delivered a paper on Limitations of the Problem of Electrolytic Deposition, while F. D. Newbury, of the American Institute of Electrical Engineers, presented a paper on Sources of Direct Current for Electrochemical Processes. H. E. Longwell, Mem.Am.Soc.M.E., read a paper on the Power Problem in Electrolytic Deposition of Metals, in which he discussed some interesting phases of the problem of power production in industries of this class. His remarks are presented below in abstract form.

In dealing with any technical problem, common sense is most useful; but technical knowledge without common sense is disastrous. I want to emphasize the fallacy of attaching too much importance to the question of mere fuel economy in a power plant, because I think there is a little tendency in this direction in the presentation of the problem that has been submitted as a foundation for this discussion. Sundry estimates are submitted as representing the problem cost of steam and electrical energy, exclusive of administration, taxes, depreciation and interest charges. The items of interest, taxes, insurance and depreciation, or more exactly, amortization, are too important to be ignored. These so-called fixed charges, or investment costs, are in general greater in amount than the total cost of labor, operating supplies and maintenance. They are especially significant in that they measure the cost of fuel economy.

To illustrate, let us consider the probable comparative performances of a high grade steam turbine plant, and a gas engine and producer plant, consisting of several 1500 kw. generating units. The electrolytic refining industry offers any investment in the interest of economy, an unusually favorable opportunity to "make good," because the investment is permitted to work at its utmost intensity continuously 24 hours per day every day in the week.

Assuming the fuel to be the highest grade of bituminous or semibituminous coal, having a calorific value of 14500 B.t.u. per lb., the gas engine and producer plant, would, under test conditions, effect a saving of ½ lb. of coal per kw-hr. over the turbine plant, or say 2 tons per annum. If the coal costs as much as $3 per ton this would mean a saving of $6 per kw-year.

The gas engine and producer plant will cost about $50 per kw. more than the steam turbine plant, and the question arises as to whether it is worth while to invest $50 in plant to save $6 a year. Naturally there will be differences of opinion as to what would constitute an attractive return on this extra investment. For my own part, I should want 6 per cent for interest, 1 per cent for taxes, 1 per cent for insurance, and 2 per cent for maintenance. Having due regard to the appalling speed with which new things in engineering become old, I shouldn't feel comfortable unless I had a sinking fund of 8 per cent to provide for the safe return of my capital. The sum of these items amounts to 18 per cent. Even with this gross return assured, I think I should be inclined to regard a 6 per cent mortgage as a more attractive investment. In my own opinion the gross return should be not less than 20 per cent per annum, so that this saving of $6 per kw-year would be too expensive if it required an extra invest-

ment of more than $30 per kw. in plant equipment. Those who are interested in the determination of the true cost of electrical energy will profit by reading a paper, Standardization of Method for Determining and Comparing Power Costs in Steam Plants, presented jointly by Messrs. H. G. Stott and W. F. Gorsuch, at the June 1913 meeting of the American Institute of Electrical Engineers.

With respect to the type of power plant best suited for the electrolytic refining of copper, I think we may safely eliminate the gas engine equipment from serious consideration. If the plant will be located where there is an abundant water supply available for condensing purposes, and where the cost of fuel is reasonable, such as to enable a steam plant to display its best economy, the gas engine plant would be a doubtful investment, even were there no especial reason why it is not desirable for this particular class of work. There appears, however, to be one reason why the proposition is peculiarly one for a steam plant, which is based on premises supplied by those actively engaged in electrolytic copper refining. According to Mr. Addicks' statement of the problem, if live steam were used for heating the electrolyte, the total steam from the boilers would be used as follows: One-half for electric power generator, one-quarter for steam driven auxiliaries, and one-quarter for heating the electrolyte. Steam driven auxiliaries are not as a rule so efficient that they abstract any serious amount of heat from the steam passing through them, so that for the purpose of heating the electrolyte, the exhaust from these auxiliaries would be practically as effective as an equal quantity of boiler steam. Therefore the boiler steam required for auxiliaries and for heating the electrolyte, would be approximately 50 per cent of the amount required for generating the electric current.

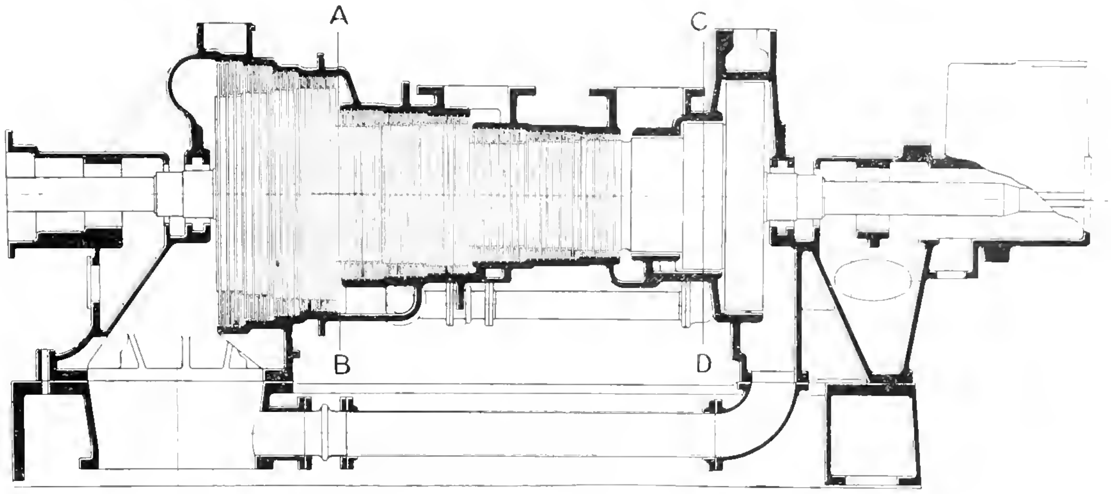


FIG. 1 SECTIONAL VIEW THROUGH A TYPICAL EXPANSION STEAM TURBINE OF THE PARSONS TYPE

I am informed by the general manager of one of the largest refineries in this country that in a plant having an output of 500 tons of refined copper per day, the waste heat boilers connected to the reverberatory furnaces forming a part of such a plant, should be capable of supplying 50,000 lb. of steam per hour. This is somewhat over 40 per cent of the steam required by the main generating units, or practically enough to op-

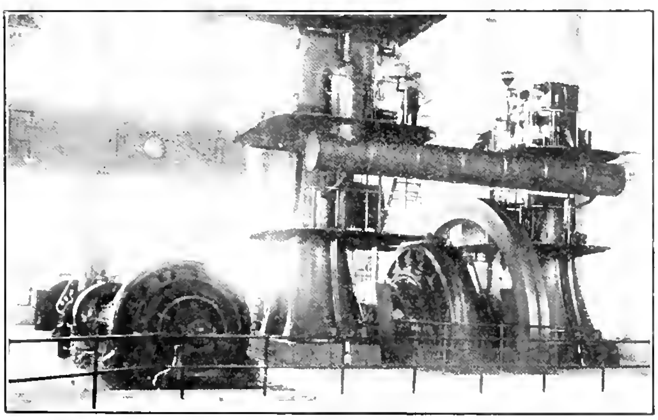


FIG. 2 A 1500-KW. GEAR-DRIVEN TURBO-GENERATOR INSTALLED BESIDE A RECIPROCATING ENGINE SET OF SAME NOMINAL CAPACITY

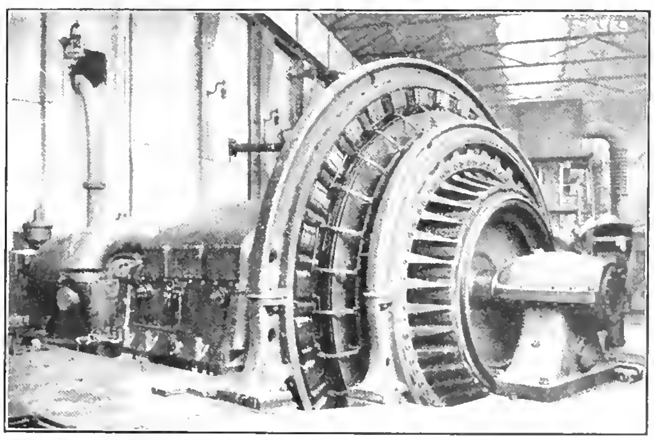


FIG. 3 A 3000-KW. GEAR-DRIVEN DIRECT-CURRENT TURBO-GENERATOR OPERATED BY THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

erate all of the auxiliaries that would usually be run by independent steam motors in a steam driven plant, and the exhaust from these auxiliaries would take care of the heating of the electrolyte. This quantity of steam is too important to ignore and even though gas-engine driven main generating units were installed it would be necessary to make use of this steam from the waste heat boilers.

As I understand it, the practical difficulty arises from the fact that while the tanks are operated continuously, it is not usual to run the furnaces on Sunday. Consequently it would be necessary to have a considerable boiler plant in reserve to be operated only one day in each week for the purpose of tiding the plant over Sunday. And so even if there were no question as to the commercial economy of a gas engine and producer plant as a general proposition, this one practical operating condition would be sufficient to rob it of all of its theoretical advantages. In a steam plant the regular boiler equipment is so flexible that it will readily take care of the fluctuations in the output of the waste heat boilers. Since with modern mechanical stokers it is not unusual to force boilers to 200 and 300 per cent of their normal rating, it is evident that no decidedly disproportionate boiler equipment would be required to carry the plant over the weekly interval in which the waste heat boilers are out of commission.

The combination of a compound reciprocating engine exhausting into a low-pressure condensing turbine looks on first consideration to be inviting, since it is generally admitted that between the limits of the usual boiler pressure and atmospheric exhaust pressure, a reciprocating engine is usually more efficient than it is customary to make the portion of a complete expansion turbine that takes care of this part of the pressure range. While the superior fuel economy of this combination seems very apparent from purely theoretical considerations, there is comparatively little available information regarding its amount in actual figures. It is not denied that this combination has its legitimate uses, but it is most certain that mature judgment is required for determining the conditions under which it may be recommended.

Admitting the hypothetical economy of the combination, let us consider the features that tend to offset this advantage. We have first increased initial cost. A low-pressure turbine will in many instances cost 75 to 80 per cent more per kw. than a complete expansion turbine. That this is reasonable may be seen readily by an inspection of Fig. 1, which is a sectional view through a typical expansion steam turbine of the Parsons type. Let us assume that the capacity of this machine is 3000 kw. What we must do to convert this 3000-kw. turbine into a low-pressure turbine of half this capacity, is simply to cut out that portion included between the two vertical lines AB and CD, and increase the inlet opening some six or eight times. Now it does not require any unusual qualifications to see that the part eliminated does not by any means represent one-half of the cost of the 3000-kw machine. Neither would any one of reasonable intelligence expect to purchase 1500-kw. capacity in a reciprocating engine for any sum remotely approaching the cost of the section that has been eliminated from the complete expansion turbine. Again, no one would seriously claim that the expense of installing the combination unit would be less than twice that of installing the single complete expansion unit, and no one would suggest that the charges for attendance, maintenance and operating supplies would be approximately equal for the two units.

There are, doubtless, cases in which the possibility of conserving reciprocating engines already in use would justify this combination type of unit, but in a plant that is new throughout its desirability is, to say the least, highly problematical. The most important installation of combination units in the world was carried out under the direction of Mr. Stott. He had the

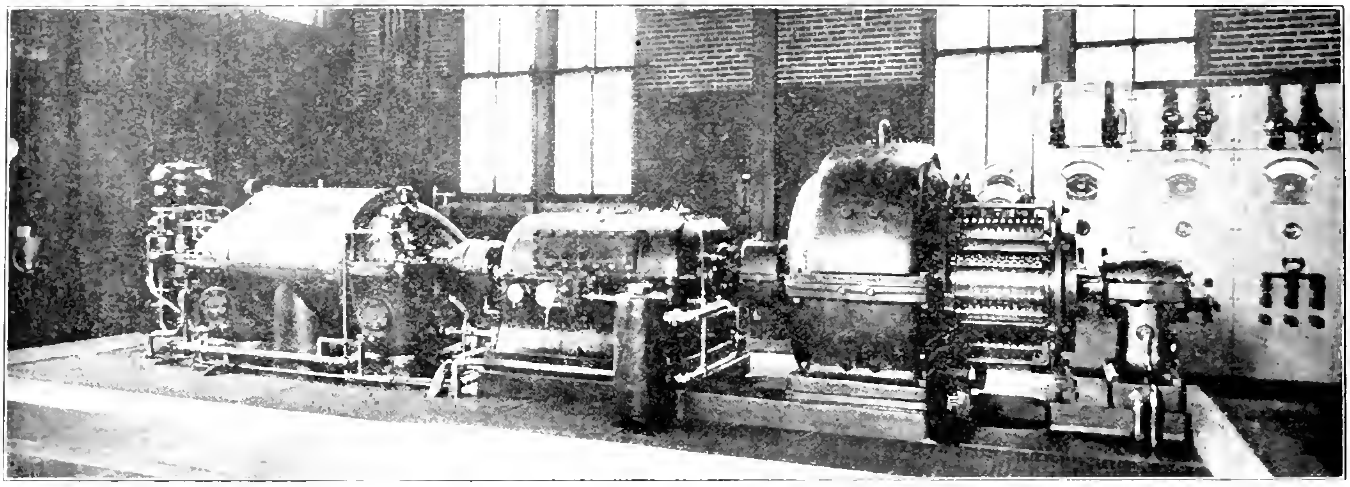


FIG. 4. A 750-KW. GEAR-DRIVEN DIRECT-CURRENT TURBO-GENERATOR IN USE BY THE LOUISVILLE & NASHVILLE R. R.

justification of conserving valuable reciprocating engine equipment which was in excellent physical condition, and there can be no question that the best possible engineering judgment was exercised in designing and executing the project.

As regards the comparative merits of compound and triple expansion reciprocating engines, and turbines, as prime movers, the trend of general practice in power plant design shows pretty conclusively that the turbine has the advantage. It has economic possibilities equal at least to those of the reciprocating engine, and markedly better when working with the high vacuums obtainable with the newer types of condensing apparatus and the copious supply of cooling water that is invariably found in places that would be regarded as favorable locations for electrolytic copper refining plants.

I speak of the economic possibilities of a certain type of prime mover rather than of its inherent economy, because the latter is inseparably associated with the type. A prime mover is not economical simply because it is a compound engine, a triple expansion engine or a turbine, but because it is economical by design. There are hundreds of triple expansion engines that are less economical than some compound engines. In fact I am not sure that there are authentic records of triple expansion engines which show sufficient improvement over the economic results of the best examples of two-cylinder compound engines to justify the added complication and expense of the third cylinder and its connections.

It is possible to design a turbine that will be less economical than a very ordinary multiple expansion reciprocating engine. On the other hand turbines are built that under suitable operating conditions give economic results that cannot be equalled by reciprocating engines of any type, however skilfully designed, if operated under the same conditions. The advocates of the turbine can afford to be unnecessarily modest, and claim no more than equality with other types of prime mover as regards steam economy, for there remain still the unquestioned advantages of lesser cost, and smaller installation expenses.

For some years the turbine was at a disadvantage in plants in which it was desirable to generate direct current, for the reason that the rotative speed of an efficient steam turbine, and the rotative speed of a reliable efficient direct-current generator are not compatible. This inability has happily been removed by the development of a reliable transmission gear, which allows any reasonable speed ratio between the turbine and the generator. This gearing has an efficiency of over 98 per cent. and has been in public use long enough to demonstrate that in point of reliability and durability it is at least on a par with any other kind of apparatus installed as a part of an electric power plant.

Fig. 2 is a view of one of two 1500-kw. geared sets installed at San Diego, Cal. The illustration gives a good idea of the size of this unit as compared with an engine driven set of approximately the same nominal capacity. One of these sets was in regular service two years on September 3, 1913, and the second was in service two years on February 15, 1914. Fig. 3 shows one of two 3000-kw. geared direct-current turbo-generator sets installed for the Cleveland Electric Illuminating Company. One of these sets was put in service a year ago January 20, 1914. It is fair to say that in this case the exhaust of the turbines is used for district heating, and the units operate only during the heating season. Fig. 4 shows a 750-kw. set owned by the Louisville & Nashville Railroad Company, which has been in service just about one year. In addition to the sets illustrated, I might mention six others of 750 and 1500 kw. capacity, all of which have been in regular service for more than two years, and the oldest of which will have been in service three years on April 4, 1915.

While the geared direct-current unit costs more than an alternating-current turbo-generator unit of the same capacity, it is cheaper and somewhat more efficient than the combination of an alternating-current unit and rotary converter. I am not in possession of reliable costs for compound reciprocating engine-driven units, but commercial experience indicates that the geared turbine-driven unit has an advantage as regards price at the factory. With freight and installation costs added, the advantage is obviously more marked.

Figures purporting to give probable plant and unit power costs are as a rule unsatisfactory because they are affected by too many variable factors. As regards plant cost, it might be said that depending on the expensiveness or simplicity of one's architectural tastes, his luck in selecting a contractor, his resourcefulness as a designer, his finesse as a buyer, the accessibility of the site selected, the state of the weather, etc., he ought to be able to build a really good turbine-driven plant of from 6000 to 9000 kw. capacity, for around $75 per kilowatt.

As regards the cost of power: if one is satisfied with investment charges of 10½ per cent per annum, if he can buy really good coal at not to exceed $3 per ton, if he is a capable manager and a careful operator, and reasonably economical, he ought, with a plant of this size, to be able to produce a kw-hr. at the switchboard with substantially 100 per cent load factor, for around 4.3 mills.

NOTES ON THE FLOW OF OIL IN PIPES

BY E. L. DYER,[1] SAN FRANCISCO, CAL.

Non-Member

At a meeting of the San Francisco Section of the Am.Soc.M.E., held February 10, the topic for discussion was The Transportation of Crude Oil in Pipe Lines. E. L. Dyer, engineer-in-chief for the Union Oil Company of California, led the discussion by reading a paper prepared with special reference to experimental work on one of the oil pipe lines of his company, to determine the various factors influencing the loss due to friction in pumping oil through pipe lines, and the derivation of formulae by which the friction losses could be calculated. An abstract of the paper and report of the meeting is given herewith.

An oil pipe line is primarily an investment, and as such, exists for the purpose of enabling its owners to derive profit either directly from the operation of the line itself, or from other associated enterprises. The time element has always been an important consideration in its construction. In this state, the production of oil has increased at such a rapid rate and with such suddenness at times, that it has been absolutely necessary to build long pipe lines on short notice, and these conditions have unfavorably influenced their design by putting a premium on practice which, while not usually preventing the pipe line from being constructed with reasonable certainty of success as an investment, has too frequently not resulted in the most profitable investment possible.

Fortunately, undertakings of this character have been safeguarded as a rule by a variety of favorable circumstances tending to offset mistakes of design. One of these has been the absence of competition, due to the costly nature of operations on a scale sufficiently large to render such competition effective, and another has been that experience has developed an empirical practice which provides reasonable protection against a considerable variation in physical conditions. As a rule, builders of pipe lines have been content to follow closely in the footsteps of others, so that we see on every hand too much slavish imitation and rule-of-thumb engineering, with too little evidence of initiative. As a matter of fact, the immense number of variables to be dealt with, particularly with California oils, is enough to warrant a great deal of conservatism. The necessity for quick action has made designers of pipe lines the victims of circumstances, and the multifarious duties exacted of most engineers connected with oil companies, together with a general lack of sympathy with research work, has discouraged investigation of the fundamental variables which are at the bottom of all pipe line design.

Hence it is that, as a rule, the oil pipe line in California, regarded either as an investment or as a purely physical problem, does not always represent the best possible solution that might be made for exactly the same conditions. The most economical pipe line for a given service cannot be determined in advance without a working knowledge of the laws governing the flow of oil in pipes in general. The determination of these laws offers the most important single problem in connection with pipe line work. Everything else depends on it. Unless the loss of head by friction can be predetermined with reasonable accuracy, every element entering into both the first and the operating costs of an installation is uncertain, and should the design be undertaken in an era of keen competition and small margins of profit, a losing venture might easily result.

In view of the importance of this phase of the subject, this discussion is confined as far as possible to points bearing upon the friction head in oil pipe lines. Neither a full nor a general analysis is attempted, nor is anything offered purporting to be a complete and final solution of the problem. The information offered is of a fragmentary and tentative character, based on observations unfortunately subject to considerable error, as will appear later, and it is hoped that it will promote discussion and stimulate investigations which the importance of the subject demands, and if possible, at the same time, be suggestive of an avenue of approach toward a logical and complete method of determining the friction head for any given oil under any given conditions.

The problem of piping oil differs from that of piping water primarily in the fact that, whereas water is a fluid of well-defined and of almost constant physical characteristics within ordinary temperature limits, oil is quite the opposite; no two oils are exactly alike and even any one oil is subject to important physical changes under variable temperature. While the flow of water through pipes offers in itself a sufficiently difficult problem, still the laws governing it have been determined empirically with sufficient exactness to meet all ordinary, practical requirements. For present purposes water may be considered as a liquid of almost negligible viscosity at all ordinary temperatures, although this is not strictly correct, as will appear later. Oil, on the other hand, is a liquid of relatively great viscosity, much affected by change of temperature. The principal difference between the two

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from a pipe line point of view lies in this question of viscosity and it is logical to suspect that any solution of oil flow problems will be found to involve viscosity in some form or other.

Viscosity may be defined as that property of a liquid which causes it to offer resistance to relative motion of its parts and to change of form. More specifically, it has been defined by Clerk Maxwell as "the tangential force per unit area of either of two horizontal planes at the unit of distance apart, one of which planes is fixed, while the other moves with unit velocity, the space between being filled with the viscous liquid."

The viscosity of any liquid may be measured in the laboratory and can be expressed either as absolute viscosity in c.g.s. or gravitational units, or else in some empirical unit. An arbitrary unit is more convenient for practical purposes, as simple apparatus may be used and no computations are required. The instrument used is known as a viscosimeter or viscometer. The type which finds most general application in this country consists of a cylindrical vessel of known volume and form surrounded by a water jacket which may be maintained at any desired temperature. At the bottom of this vessel is a small circular orifice of definite dimensions with a definite form of entrance. A measured quantity of the liquid to be tested is put into the vessel and the time required to run through the outlet in seconds is taken as the viscosity of that liquid at that temperature. Thus, if the time is 30 seconds, the viscosity is called 30. This figure in fact represents the approximate viscosity of water at a temperature of 60 deg. fahr., and a typical fuel oil of 16 deg. to 17 deg. Bé. has a viscosity of about 9000 at the same temperature.

It will be seen that the phenomena occurring in this instrument do not differ radically from those in a pipe line except that the entrance effects are relatively large and the operation is on a small scale, under variable head and under constant temperature. As previously indicated, the viscosity of oil varies over a wide range with change of temperature. Thus, a certain oil of 16.6 deg. Bé. gravity has a viscosity of 200 at 200 deg. fahr. and about 13,000 at 50 deg. fahr. In other words, at the lower temperature it takes 65 times as long to flow through the standard orifice as it does at the higher temperature. The curves in Fig. 1 illustrate the change of viscosity for several crude oils with change of temperature. It is worth noting in passing that the heavy and the light oils tend to show about the same viscosity at a temperature of 200 deg. fahr., and as we have seen that viscosity is the measure of the resistance of an oil to change of form, these curves should convey a lesson to those who are interested in cutting down the steam required for atomizing oil in burners. The same sheet also shows the effect of change of temperature on water; although the change is not great as compared with oil, still it is quite noticeable.

Having noted the effect of temperature variation on the viscosity of oil, it will be instructive to make similar observations on the effect of temperature on the

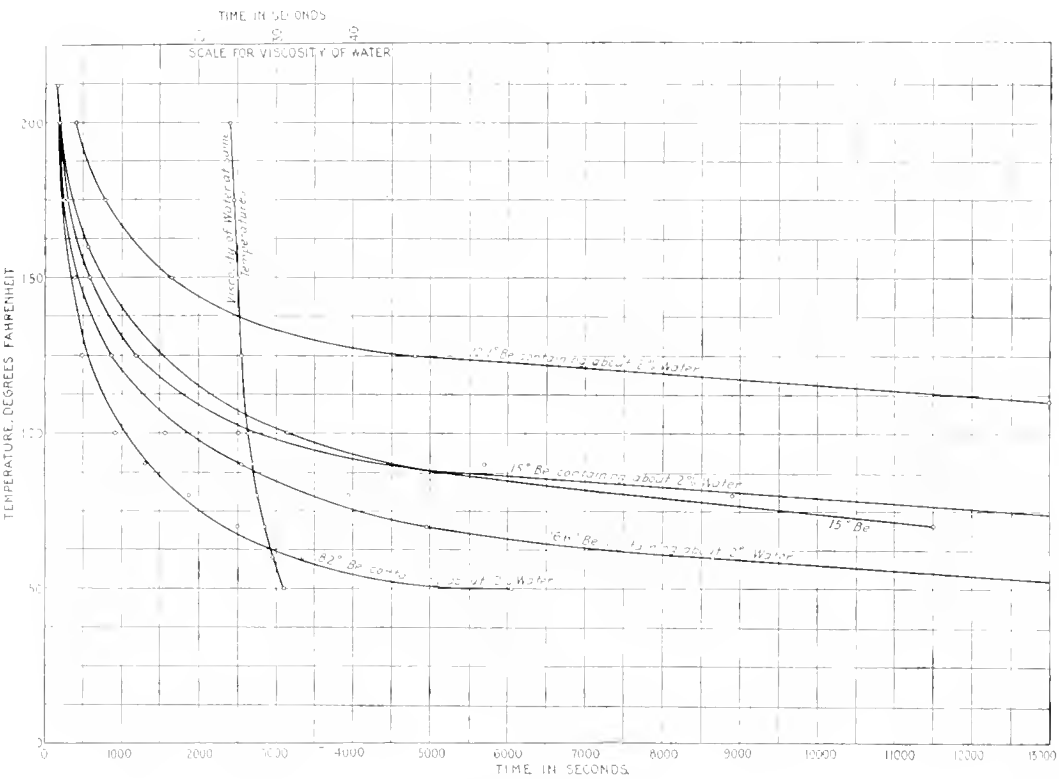

FIG. 1 CURVES SHOWING RELATION OF VISCOSITY TO TEMPERATURE IN SEVERAL DIFFERENT CRUDE OILS

resistance to flow of oil in pipe lines. In making these observations it has been convenient to use the Chezy formula in the form given by Unwin for use with water. This formula is largely used by engineers and may be expressed as follows:

$$h = 0.1008 \frac{\zeta Q^2 L}{d^5} \quad \ldots\ldots\ldots\ldots \quad 1$$

Where ζ = an arbitrary coefficient depending on diameter, velocity and roughness of surface

- h = loss of head, feet
- Q = quantity, cubic feet per second
- L = length, feet
- d = diameter, feet

Transposing, we have

$$\zeta = \frac{hd^5}{0.1008 Q^2 L} \quad \ldots\ldots\ldots\ldots \quad 2$$

By use of this last expression, ζ can be determined without difficulty for any oil in a pipe line by a series of observations, for any temperatures, size of pipes, rate of flow, etc. At the same time the viscosity of the same oils over the same range of temperatures can be determined with a viscometer. Two sets of curves can then be plotted, one showing the relation existing between temperature and ζ as observed in a pipe line and the other, the relation between temperature and viscosity as determined by the viscometer. From these curves two empirical equations may be determined and t (temperature) eliminated, giving ζ in terms of viscosity. By substituting this value of ζ in equation (1) we would then expect to have an expression of the form

$$h = \frac{cQ^2 L f(\eta)}{d^5}$$

where c is a constant and $f(\eta)$ represents some function of η, the coefficient of viscosity. By a series of tests we might reasonably expect to be able to determine by these means such constants as would enable us to predetermine the drop in pressure for any oil in any pipe line by measurements of viscosity made in the laboratory.

To make the determinations covering all possible conditions naturally requires an extensive equipment, patience and sustained effort. I have already indicated some of the obstacles in the way of the engineer of the oil company, preventing work of this character being done. Nevertheless it has been possible to keep records of everyday operations which afford some approximation to accuracy. In one place which I have had under observation for some years there are two oil pipe lines respectively 6 in. and 8 in. in diameter and about 2 miles long, which are in intermittent service as occasion demands, carrying a variety of oils, usually at a fairly constant rate of about 500 bbl. per hour. The temperatures available and the rate of flow are such as commercial considerations dictate, so that it has been impossible to make changes for experimental purposes. The mean temperature in the pipe line averages about 110 deg. fahr. The lines are buried for practically their entire length, although they are exposed for considerable distances, and for the most part they are practically straight. They are equipped with gages and thermometers and the elevations are of course known. The gages are of ordinary commercial type and therefore at times very unreliable, but they are, however, calibrated at more or less frequent intervals by a standard gage which is itself checked from time to time on a dead weight tester. Errors of pressure have undoubtedly crept in; the observations as to quantities, temperatures, etc., are made by the regular operators and are also known to be inaccurate at times. In general, commercial requirements do not permit of the conditions being varied at will for purposes of test

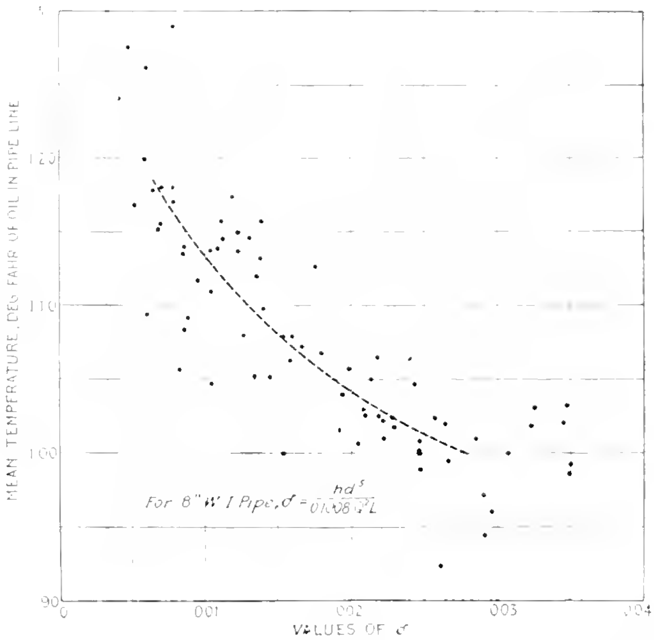

FIG. 2 CURVE SHOWING APPROXIMATE RELATION BETWEEN VALUE OF ζ AND TEMPERATURE IN 8-IN. PIPE LINE

and in other respects they are not ideal. It is particularly unfortunate that higher rates of flow and ranges of temperature have not been available, but their absence should not interfere with the general truth, of the deductions which I am about to make.

Values of ζ have been computed for the two lines for some 120 or more runs. Those for the 8 in. line have been analyzed and tabulated and the results given here are for that line. Values of ζ have been plotted against temperature as shown in Fig. 2, the temperature used being the arithmetical mean of the temperatures at both ends of the line. The logarithmic mean would probably give greater accuracy but there are so many other uncertainties that it is probable that the fall of temperature in the line is not strictly uniform anyway. The oil represented in the t-ζ curves varies in gravity from 16 to 17 deg. Bé. There are a few freak points, but on the whole a fair curve can be drawn which is reasonably representative of the average.

While the curve may not be strictly correct, it is evident that it unmistakably shows that ζ decreases regularly with increase of temperature.

If we compare the t-ζ and t-η curves we will at once be impressed by their similarity and if we examine the viscosity curve for 16.6 deg. Bé. oil, particularly that portion which lies between the same temperature limits as the t-ζ curve, it will be seen that the similarity is very striking. In fact, plotting the two on the same sheet with the same temperature scale and the ζ scale suitably adjusted, the curves can be made practically to coincide. By means of this expedient I have deduced the relation

$$\zeta = \frac{\eta - 930}{30667}$$

Now if this value of ζ be substituted in equation [1] we have

$$h = \frac{Q^2L \ (0.001075 \ \eta - 1)}{327d^5} \quad \ldots\ldots [3]$$

This relation has been checked in several instances and the agreement with observed facts was as close as might be expected under the conditions. You will notice that with viscosity of 930 the expression becomes zero and indicates one of the limits of the formula. The formula is not proposed for serious use, but is given as a sample of one method of approach. With an accurate series of observations there is no reason that I see why a formula cannot be developed in this way to cover all conditions. If we inspect the temperature — viscosity curves again it will be seen that what is true of 16.6 deg. Bé. oil between the temperatures of 100 and 120 deg. appears also to be approximately true for

12 gravity oil between 145 and 165 deg.
15 gravity oil between 110 and 140 deg.
18 gravity oil between 75 and 100 deg.

because the curves are of the same form and general slope between those temperature limits.

I have digressed slightly from the course I had mapped out, wherein I had intended to show how ζ might be expressed in terms of η by equating the value of t found from the empirical equations of the temperature-viscosity and temperature-ζ curves.

H. E. Boner, engineer of tests of the Union Oil Company, has developed the empirical equations for both the sets of curves shown, and finds that the equation of the t-η curve is

$$\eta = \frac{(584.5)^{5.42}}{(t + 50)} + 65$$

from which

$$t = \frac{584.5}{(\eta - 65)^{0.1843}} - 50$$

He has also derived the empirical equation for the t-ζ curve, which is

$$\zeta = \left(\frac{70}{t + 5}\right)^{8.81}$$

from which

$$t = \frac{70}{\zeta^{0.1135}} - 5$$

By equating the two values for t thus obtained, the value of ζ is found to be

$$\zeta = \left[\frac{1.555}{\frac{13}{(\eta - 65)^{0.1843}} - 1}\right]^{8.81}$$

Substituting this value for ζ in equation [1] we have

$$\eta = \frac{0.1008Q^2L}{d^5}\left[\frac{1.555}{\frac{13}{(\eta - 65)^{0.1843}} - 1}\right]^{8.81}$$

This expression gives values for the lost head somewhat higher than the relation first deduced in equation [3] and as far as it has been checked, with no greater accuracy. It, however, offers greater promise of extension over a wider range of temperatures. It will be noted that it does not become zero until the coefficient of viscosity becomes as small as 65. I might say that the t-η and t-ζ empirical equations when plotted give curves agreeing very nearly with the curves plotted from the original points. In considering these equations, it should be borne in mind that they are developed from a limited series of tests made on but a few oils over a narrow temperature and velocity range.

If an attempt is made to apply them to conditions differing materially from those under which the runs were made, it will be found that correct results will not be given. Therefore I wish to emphasize the point that I have not been attempting to offer a solution of the problem, but rather to indicate a promising method for arriving at the solution. The velocities used in the above determinations are lower than those found in practice in the field, and this is an important point of difference. The same method of development can be employed to determine the effect of velocity, but this has not been done as yet. I feel certain, however, that the methods indicated if carried out on an extensive scale and under test conditions, can be made to yield reliable results and if this actually proves to be the case, the starting point in pipe line design may be in the laboratory, commencing with the viscosimeter.

DISCUSSION

WYNN MEREDITH. The commercial considerations have, as Mr. Dyer has stated, prevented the obtaining of precise data of existing lines as to the governing factors in the pumping of California oils. The development of empirical formulae to fit conditions within certain limits is very interesting. The temperatures used in pumping California oils run from about 140 deg. fahr. down to whatever it comes to at the delivery station, the stations being usually 12 to 14 miles apart. This temperature is about as high as can be used with the light oils without losing valuable gases; with the heavier fuel oils the temperature can be raised very much higher without serious loss, because they have very little to lose.

The general practice in pumping is to have about 800 lb. pressure at the initial station. Aside from the distances between stations, the rate of loss of heat is largely affected by the nature of the ground traversed by the pipe line, and has a governing effect upon the proper location of stations. One

curious thing that happens in pumping heated heavy oils in a line with a normal capacity of say 20,000 bbl., is that when operating at a rate of from 6,000 to 8,000 bbl., the initial pressure is actually greater than it is when pumping up to 15,000 or 20,000 bbl. This follows naturally, because at the higher rate the oil carries the heat further and maintains a greater fluidity throughout the line. But it is rather curious to see a pump working under one-third capacity with a pressure even greater than when running at full capacity.

The economic pumping of heated California oils requires, among other things, the proper locating of pumping stations with reference to distance between stations, due consideration being given to differences in altitude. A correct formula for the determining of friction head would be of great value in the calculations. Experience with existing lines has shown the limitations to a considerable extent. Fortunately, the errors of calculation with present knowledge are capable of fairly simple correction by the addition of somewhat larger pipe on the delivery end in the event of stations being located slightly too far apart.

The method of equalizing different divisions of a pumping line may also be used to maintain the capacity when it is required to pump heavier oils, which usually follow upon the decline of an oil field. This method of correction is exactly similar to that used in electric circuits, wherein the load is increased beyond originally calculated quantities, and additional copper is inserted to keep the drop within economic limits; only, in the case of an electric circuit, the copper is usually put on the pumping end instead of the delivery end, the latter location being more efficient in the case of a hot oil line on account of temperature conditions.

H. W. Crozier. I have been doing considerable work on this problem, but have attacked it in an entirely different way. Instead of attempting to calculate the head only, I have been calculating the hydraulic grade for a whole pumping unit, that is a pumping station and the pipe extending to the next pumping station. The hydraulic grade line which the hydraulic engineers have used for many years is a familiar device. It consists of a sloping straight line so drawn that one end intersects the surface of the water in the reservoir supplying the pipe under consideration (neglecting entrance losses) and the other end coincides with the surface of the water in the terminal tank or reservoir. The distance between the hydraulic grade line and the pipe at any point is proportional to the pressure at that point and the slope of the line is proportional to the friction loss in the pipe.

When considering heated California oils instead of water, the hydraulic grade line is no longer a straight line but a curved line which droops as the distance from the pumping station increases, due to the drop of temperature caused by heat losses due to radiation and conduction through the ground in which the pipe is laid. The reason I have been giving so much consideration to the hydraulic grade phase of this matter is on account of the fact that we have been working on mountain pipe lines; these are altogether different from valley lines, where certain definite conditions exist in each station. On one mountain line surmounting a considerable summit, four pumping stations, only a few miles apart, pump the oil up the mountain slope to the summit while on the down-hill slope the stations are spaced from 18 to 26 miles apart, depending on the slope. Pumping stations on this same line serving relatively level sections are 13 miles apart.

During the construction of that line everybody foresaw trouble in getting the oil uphill. My contention was that the limitation of the line would be, not in getting the oil up the hill, but down, my reason being that there was ample heat in the oil to keep the temperature high enough to hold the oil in a fluid condition in the 6-mile ascending sections; but in the 22 and 26-mile descending sections it was a different thing altogether, as the curves in Fig. 1 illustrate very clearly. As the temperature drops due to loss of heat the viscosity increases with increased rapidity; hence on the long descending sections the friction increases rapidly and a limit is reached at which it is necessary to install a pumping station with its heaters to pump the oil along. By using a hydraulic grade line platted as accurately as possible, this can be laid out on the profile of the line, and the pumping stations located with considerable accuracy.

Referring to the statement made by the author that equation [2] was correct for any definite temperature, I would like to point out a question of premise. The statement is correct, but in making a test on a pipe line there are no definite temperatures; there is a certain temperature at one end of the line, and a certain temperature at the other end of the line, and I think more stress should be given to the temperatures between the two. It is not safe to use the average; it is much safer to use an integrated value, which can be obtained with a planimeter. The fact that the line goes through a variable country, with different soil conditions and different rate of radiation, is the problem that is confronting the engineer working in difficult country, or country subject to overflow, and it is very difficult to estimate what temperature you are going to get.

Another problem which is perhaps of as much importance as the question here, is to predict the temperature at the end of the line. I have been working particularly on long pipe lines, for instance, where there are a series of four or five pumping stations pumping oil over a mountain range and then a long drop, say a 4000 or 5000 ft. to the seaboard, and the problem is to calculate the temperature gradient; we know the temperature at the initial point and wish to calculate the temperature at the terminal, so we can determine between what limits to take the viscosity curve illustrated in Fig. 1, and thus calculate the capacity of the line. Satisfactory equations have been worked out and partially checked with observed data.

In regard to the matter mentioned by Mr. Meredith, it seems extraordinary that such a condition should occur where pumping stations are operating at say one-third speed, but such actually is the case; and it is due to the loss of heat as can be readily seen by examining the temperature viscosity curves. The heat lost is proportional to the temperature and surface of the pipe, so when the velocity is low, the heat losses being the same, the oil rapidly cools, increasing in viscosity and friction until the total head due to friction is greater than when the velocity is higher when there is more oil passing to contribute heat to make up the heat losses.

A. C. McLaughlin[1]. From the standpoint of an operating oil man, it has always seemed to me that the engineer, in approaching the question of the transportation of oil through

[1] Superintendent of Operations, Kerr Trading & Oil Co., San Francisco, Cal.

pipe lines, is too much inclined to take as his point of departure the transportation or pumping of water through pipe lines, the laws of which are well known. The transportation of oil is an altogether different problem. In the first place, ordinary crude oil is not a simple homogeneous liquid such as is water, but is a very complex substance, composed of compounds of carbon and hydrogen, which in themselves are simple, but which exist in petroleum in almost bewildering number. In crude oil we find something like eight normal series of hydrocarbons, each series being represented by a large number of compounds differing slightly from each other in physical characteristics. In addition to these ordinary hydrocarbons in petroleum, which we may consider as the essential constituents, there are a great many impurities in the form of sulphur compounds and nitrogen compounds. These impurities are in such large proportions at times as profoundly to influence the physical characteristics of crude oil. For example, in some California crude oils as much as 20 per cent of the volume of the crude oil consists of nitrogen compounds.

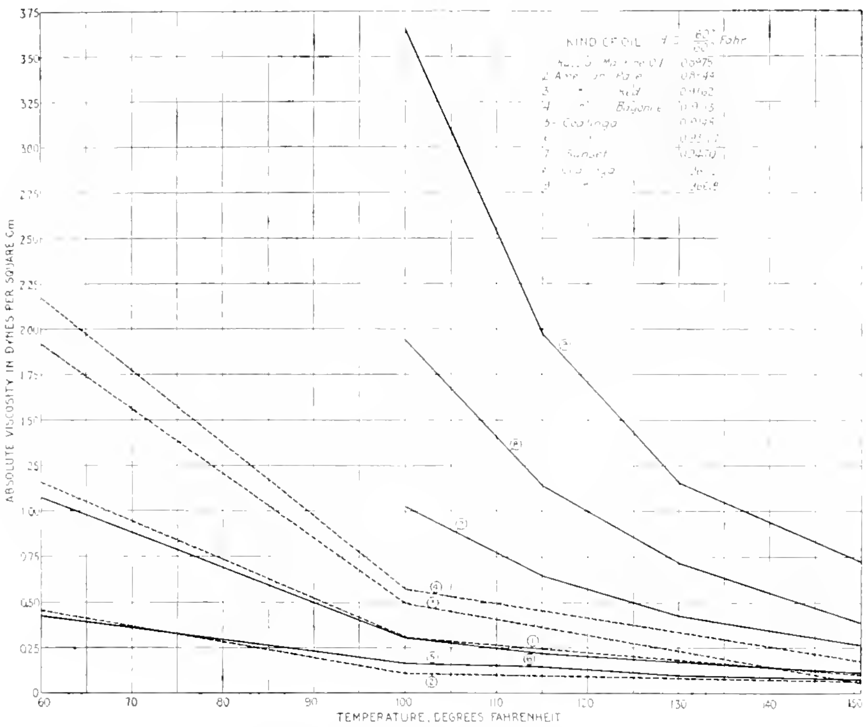

FIG. 3 VARIATION IN ABSOLUTE VISCOSITY, IN DYNES PER SQ. CM. WITH CHARACTERISTIC CALIFORNIA CRUDE OILS

Since each series of hydrocarbons is composed of members differing but slightly from each other in physical characteristics, the viscosity, boiling point, specific gravity, etc., and since each series differs in the same characteristics from each other series, it follows that rarely two samples of crude oil are precisely alike. It also follows that if one is to predict with accuracy the precise actions of a given crude oil under given conditions of pressure and temperature, it is necessary that he know the constitution of the crude oil and the physical characteristics of each of its components, which, of course, is impracticable. Therefore the practical pipe line man attempts, in so far as possible, to obtain a mixture of a large number of crudes, since it is only by getting such a mixture that he can obtain even approximately constant physical characteristics. On the other hand, he is limited in his mixing crude oils by the fact that different crude oils have different values and must be kept separate. In general, however, it is the practice of the pipe line companies to mix their crudes as much as commercial requirements will allow.

Furthermore, examination into the chemical constitution of crude oil has shown that instead of dealing with a homogeneous fluid like water, we are dealing with a solution of a large number of solid substances in an equally large number of liquids. For bringing out the result of this feature, I have prepared a number of curves, Fig. 3, showing the absolute viscosity in dynes per square centimeter of a number of characteristic California crude oils varying in gravity from 14.9 deg. Bé. to about 23 deg. Bé. An inspection of these curves shows that above a certain temperature each crude oil has a fairly constant viscosity, but that at that certain temperature the viscosity changes very rapidly with drop in temperature. This is explained by the fact that above the given temperature all of the constituents of the crude oil are liquids and the mass behaves as a liquid of approximately constant viscosity. At this certain temperature, which we may call the critical temperature, the solid components begin to segregate from the mass of the liquid and the viscosity of the oil begins to change with great rapidity. The result of this is that the practical pipe line man in pumping California oil tends more and more to keep the crude above this critical temperature, as it is only above that temperature that he can figure with any degree of accuracy. It would therefore seem that successful pumping of California oil will be brought about by successful methods of heating and successful methods of insulating the lines.

It is observed in pumping hot crude oil through pipe lines that the temperature falls with comparative rapidity during the first few miles of its passage through the line, and that the rate of fall of temperature changes very suddenly and the loss of heat is comparatively slow for the balance of the distance into the next station. The explanation of this action is to be found, I believe, in the nature of the crude oil. In the first few miles of the pumping, the crude is above its critical temperature and acts approximately as a homogeneous fluid. About 3 to 5 miles from the initial station the critical temperature is reached, the heavy hydrocarbons begin to segregate and form a coating on the inside of the pipe which protects the balance of the crude oil into the next station. Another factor to be taken into consideration is the specific heat of crude oil, which is only 0.45 as compared with water as unity. This means that for a given loss of heat, the crude oil will drop twice as fast in temperature as water would.

Another factor which comes in is the matter of mixture of

oils in pipe lines, which is a matter that has recently aroused considerable interest on account of the so-called Common Carrier Pipe Line bill. In the case of eastern crudes (Pennsylvania crudes and other light oils), where the heavy hydrocarbons are carried in solution at ordinary temperatures, it has been found that crude oils mix or contaminate each other in passing through a pipe line in plugs, to the extent of about 10 per cent of the total capacity of the line. This was worked out by Professor Shoter of Cornell University during the Standard Oil Company litigation. Now in California crude oil, where are those heavy hydracarbons condensing or segregating on the outside of the pipe line, we naturally get a very much greater mixture than in Pennsylvania. In fact, nobody knows how great it is; but no doubt it would be a valley; and my experience, from tests I made, was that the oils from Maricopa had the least viscosity of any oil I tried.

TABLE 1

Oil District	Average Data, No. Samples Used	Gravity, Beaumé, Deg.	Viscosity, Using Egler Viscometer at 20 Deg. Cent., Seconds
Kern. . .	10	15.[illegible]	915
Midway	20	16.[illegible]	518
Sunset. .	25	11.[illegible]	527
McKitt	26	16.9	200
Coalinga.	62	17.[illegible]	341

Roughtly speaking, tests of 12 gravity Maricopa oil had no greater viscosity than 14 gravity Kern oil. Bulletin No. 19

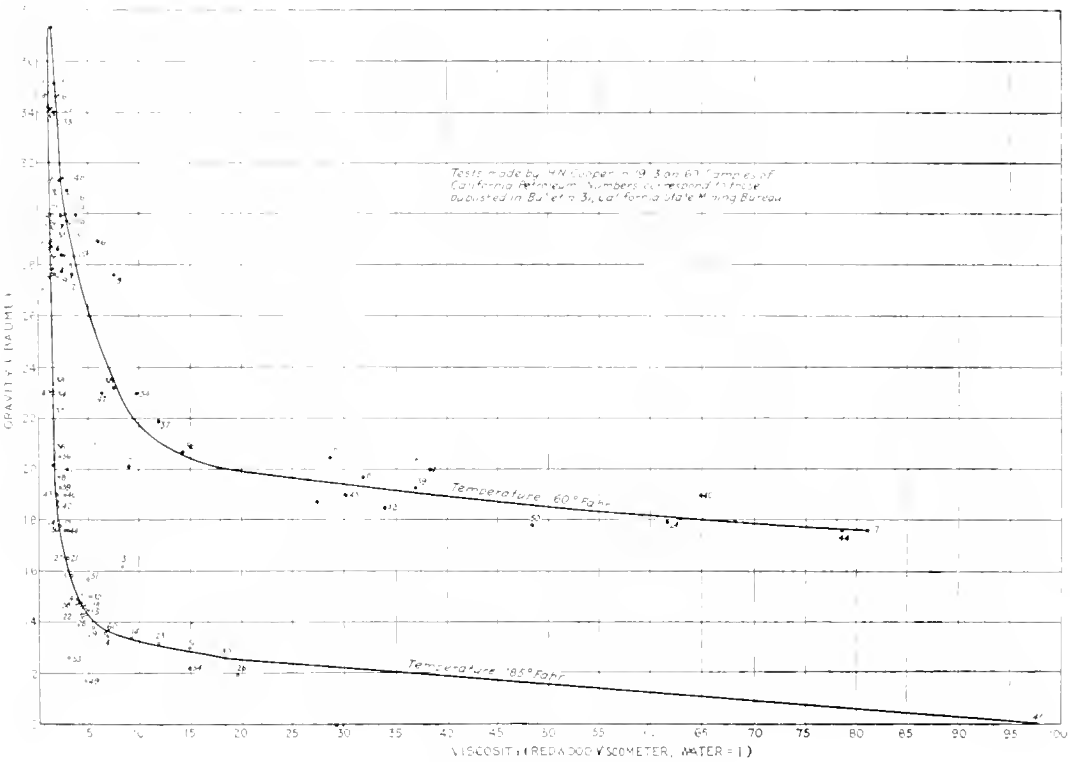

FIG. 4 CURVES SHOWING RELATIONS BETWEEN GRAVITY AND VISCOSITY OF CALIFORNIA CRUDE PETROLEUM

very important feature in pumping batches of oil through pipe lines.

R. P. McLAUGHLIN.[1] The curves in Fig. 4, showing the relation of viscosity and gravity of crude California petroleum, are presented with the idea that they may call attention to some points that have not been commonly recognized. Development of the oil industry in this state has been so rapid that most men actively engaged in it have had too little time to stop and summarize. Too frequently a few observations have been the basis of statements that no general rule could be formulated.

ARTHUR F. L. BELL.[2] There is a very notable difference in the viscosity of oil in different fields, especially the Santa Barbara field. The Santa Barbara oils of the same gravity show a marked increase in viscosity over the oils of the of the Bureau of Mines gives the data presented in Table 1.

A. C. McLAUGHLIN. Crude oils vary in viscosity, depending on the composition of the crude. In a paraffin crude oil, the drop in viscosity with the temperature is very much less than it is with the so-called asphalt crude oil. Of course there is no such thing as an asphalt and a paraffin crude oil except as concerns the end members of a series. All crude oils are to a certain extent paraffin crude oils, and all paraffin crude oils are to a certain extent asphalt crude oils. For example, we have the Pennsylvania characteristic at one end and the California at the other. But it is a fact that paraffin hydrocarbons decrease in viscosity with temperature very much more rapidly than the so-called saturated hydrocarbons, which are composed of those asphalt crudes. Most of those curves plotted are not curves of viscosity, but time of flow; and in examining them it will be found that they are very different looking curves from the true viscosity curves when the density of the oil is eliminated.

[1] Petroleum Dept., California State Mining Bureau, San Francisco, Cal.

[2] Chief Engineer, Associated Oil Company.

H. T. CORY. In regard to Mr. McLaughlin's comment that what is called viscosity is not the true coefficient of viscosity, doubtless the men in the oilfields are using a coefficient that they think better serves their purpose than the true coefficient of viscosity. The Beaumé reading and the specific gravity are both intended to express a certain physical characteristic of oil; and are simply two ways of expressing that characteristic. In this particular case these two ways are sufficiently distinct. However, this "viscosity" which has been used in the discussion here, and the real coefficient of viscosity, are so entirely different that the use of the term "viscosity" seems to me very unfortunate. Apparently some of the oil terminology is pretty far from being standardized.

ROBERT SIBLEY. The standardizing of some of the units of measurement that are utilized, for instance, the measurement of gravity, the Beaumé scale, is a point that concerns our San Francisco Section. Recently, the Standard Oil Company issued Bulletin No. 4, in which was described a conversion of specific gravity readings into the Beaumé scale, and *vice versa;* and also was given an entirely different formula than is found in Kent's Mechanical Pocket Book and that adopted by the United States Bureau of Mines. In other words, there is evidently a conflict in the adoption of an empirical relationship such as the Beaumé scale; and it would seem to be one function of this Society, as long as we are concerned largely with the manipulation of crude oil, especially its use in the industries, to add its weight somewhat in standardizing those relationships if possible.

R. P. MCLAUGHLIN. It seems to me the relation which exists between the viscosity and the gravity of California crude oils might help to standardize some of these discussions. I have plotted a number of viscosity tests in the form of curves and there seems to be a definite relation between viscosity and gravity. The data for these curves are published in Bulletin No. 31 of the California State Mining Bureau and cover in the neighborhood of 60 different samples of oil from all parts of the state. The temperature viscosity curves are for two different temperatures, namely, 60 deg. and 185 deg. fahr.

H. W. CROZIER. I would like to ask Mr. McLaughlin for further information about those curves. My experience is entirely at variance with his results and, while we have always known that the viscosity was in some way related to the gravity, so many exceptions have come to our notice that, in exact work, we do not consider that knowledge of the gravity of an oil sample gives us very much information about what its performance will be in a pipe line.

R. P. MCLAUGHLIN. The curves are, in general, correct and show the relation between gravity and viscosity at the definite temperatures used, but, as Mr. Crozier stated, there are a number of samples which differ widely from the average shown by the curve, and I would particularly call attention to samples Nos. 40 and 56, which have viscosities over twice that given by the reading from the curve, while samples Nos. 42 and 50 are very much below the readings of the curve. Also in regard to some of the oils from the Kern and Los Angeles fields of about 12 and 13 gravity, there are four samples: 53, 54, 26 and 49, which depart widely from the 185 deg. curve. These curves may be used in a general way for the determination of the probabilities, but, as Mr. Crozier has pointed out, it is advisable to sample and test the oils before making a prediction as to what they will do in a pipe line, and it will be noted that many of the exceptions depart widely from the average condition represented by the curve, which is, of course, a generalization.

PRESENT TENDENCIES IN RAILROAD WORK

PAPERS PRESENTED AT A JOINT MEETING IN BOSTON

THE MODERN LOCOMOTIVE

By HENRY BARTLETT, BOSTON, MASS.

Member of the Society

Twenty years ago the express passenger engine was of the eight-wheel type with 18 x 24 in. cylinders, a 58 in. boiler carrying 160-lb. of steam, a grate area of 19 sq. ft., a tractive power of 15,300 lb. and a weight in working order of about 50 tons. Since that time larger eight-wheel passenger engines have been built, then the Atlantic type of locomotive, and now the Pacific type has been reached as the standard express locomotive on many railroads. The standard Pacific type express locomotive of the Boston and Maine Railroad has 22 x 28 in. cylinders, a 68 in. boiler carrying 200 lbs. of steam, a grate area of 53.2 sq. ft., a tractive power of 31,600 lb. and a weight in working order of 235,000 lb. These locomotives have also many improvements, including a superheater, piston-valves, Walschaert valve-gear, a brick arch, pneumatically operated fire-door, flexible stay bolts, extended use of cast-steel, a design of trailing truck permitting the use of a deep wide fire-box.

These engines show an increase of 83 per cent in capacity and at the same time an increase of 80 per cent in weight over the standard of twenty years ago. This increase in weight in about the same proportion as the power may perhaps suggest a lack of refinement in detail, but upon investigation it will be seen that this apparent disparity does not actually exist as one of the most characteristic improvements in locomotive design has been the introduction of the trailing truck which makes it possible to obtain ample heating surface and larger grate area; this enables the locomotive to deliver its rated tractive power under all service conditions and to do it with the consumption of less fuel.

Abstracts of papers presented at a joint meeting held at Boston on February 4 by the American Society of Mechanical Engineers, the Boston Society of Civil Engineers and the American Institute of Electrical Engineers.

Local conditions have developed larger passenger engines on some other roads, and the introduction of heavier steel cars will require still greater power to handle them. An example is the famous No. 999 on the New York Central Railroad with which was inaugurated the Empire State Express at the time of the Chicago Exposition, and in comparison with this the Pacific Type engine that now handles the Twentieth Century Limited between New York and Chicago. In these engines, the increase of 100 per cent in tractive power and 118 per cent in weight is a mute testimony to the rapid growth in weight of rolling stock as well as in passenger traffic. An interesting feature of the old No. 999 locomotive was the water table extending the full length and width inside the fire box as a substitute brick arch; there can be no doubt but that the increased heating surface and circulation obtained in this way was an important factor in the phenomenal success of that engine, but today we are obtaining similar results in an easier way with the brick arch supported on water tubes.

The development of twenty years on the Rock Island Railroad has been to the use of the mountain type of locomotive, the latter being designed to haul heavy passenger trains over 1 per cent grade at moderate speeds and yet be capable of attaining speed of from 50 to 60 miles per hour on levels. The increase in tractive power here is 138 per cent and in weight 156 per cent. One of the best examples of modern locomotive design is a locomotive that was built by the American Locomotive Company for the Pennsylvania Railroad for testing out purposes. This locomotive which is of the Pacific type, has been given a long try-out at the testing plant at Altoona, at speeds ranging up to 85 miles per hour. Notwithstanding the immense power and weight of this engine, it has delivered a horse power hour on 16.4 lb. of water and 2.66 lb. of coal, establishing a record in this respect; the best performance of twenty years ago was a horse power hour on about 27 lb. of water and 4 lb. of coal. This remarkable locomotive showed an evaporation of 6500 gal. of water per hour and develops a draft in front of the diaphragm of 19.6 in. of water. The maximum coal consumption in these tests was 9700 lb. (4.8 tons) per hour, which was accomplished with stoker firing; in this manner about 50 per cent greater boiler capacity was obtained than would have been possible with hand firing.

Twenty years ago, ten-wheel locomotives were in common use for freight service. The standard freight engines on the Boston & Maine Railroad at that time, had 19 x 26 in. cylinders, a 58 in. boiler, carrying 150 lb. of steam, a grate area of 19.5 sq. feet, a tractive power of 20,600 lb., and a weight in working order of 116,000 lb. The present standard freight engine of this road is of the consolidation type, with 24 x 30 in. cylinders, a 68 in. boiler, carrying 180 lb. of steam, a grate area of 53.5 sq. feet, a tractive power of 43,409 lb. and a weight in working order of 210,500 lbs. This engine has also the latest features of design such as superheater, Walschaert valve gear, piston valves, a brick arch, pneumatic fire-door opener, etc., the increase in this class of engines being 90 per cent in power and 81 per cent in weight.

The transportation of freight is the most important problem that the majority of railroads have to consider, as it produces the largest part of their gross revenue and consumes the greatest proportion of their operating expenses. In considering the best type of locomotives we are confronted with a great variety of requirements which must be met in conducting this traffic. The consolidation type is giving good service where traffic conditions are suited to its limitations, that is, low or medium speed; as a type, it carries a greater proportion of weight on its driving wheels than any other road-engine, and in that respect is the most logical type to select for the above mentioned class of traffic. As the demand came for more rapid movement of freight trains, more powerful consolidations with larger driving wheels were developed, but they did not fill the requirements as expected because of lack of boiler capacity to furnish steam at the higher speed, and also the fact that the larger driving wheels had restricted the depth of the fire-box to such an extent that a large part of the heating surface was valueless. This has resulted in the development of what is called the Mikado type of engine which is really a consolidation with a trailing truck which permits the application of a boiler large enough to furnish steam for the maximum requirements and at the same time give ample room for a fire-box of the requisite area and depth. This type is the latest word as a fast freight locomotive, a large number having been built in the last year or two.

The Mallet type or articulated locomotive has made it possible for many roads to increase greatly the tonnage over a division on which a short heavy grade absolutely limits the train load to a fraction of what could be hauled over the remainder of the division and where it is too expensive to reduce the grade. Some enormous Mallet locomotives have been built of recent years, one being tested out by the Pennsylvania Railroad which has evaporated 71,000 lb. of water and consumes 15,000 lb. of fuel per hour; in this engine both sets of cylinders are simple, whereas usually Mallet locomotives are of the compound type. The fuel consumed at the above rate was 86 per cent of two consolidation locomotives of equal aggregate power.

The greatest advance in locomotive development in recent years has been the perfection and application of the high-temperature superheater. Although introduced extensively only a little over two years ago, it has proved its value so undoubtedly that today there are over 7,000 locomotives with superheaters. This device makes it possible to reduce very greatly the

amount of fuel consumed and what is fully as important also, offers a method of obtaining power without exceeding the capacity of the fireman. Among the many attempts that have been made to improve and insure complete combustion, the Gaines fire-box and combusting chamber is an example; in this device, a large volume of heated air is introduced into the fire-box through tuyeres in the vertical wall which materially improves combustion. An important advantage of this type of fire-box is the means it offers of getting ample depth above the grate in designs with shallow throat sheets.

TRACK

By A. B. Corthell,[1] Boston, Mass.

Non-Member

The first steel rails made in this country were rolled at Danville, Pa., in 1845. Other rollings were made in the same year by the Boston Iron Works, the Trenton Iron Works, the New England Iron Co., and the Phoenix Iron Co. The first Bessemer rail made in the United States was rolled in Chicago in May, 1865; the first Bessemer steel rails to be produced on a commercial order, were rolled in Jamestown, in August 1867. The introduction of the Bessemer process thoroughly revolutionized the art of rail manufacturing and the ultimate effect on railway building and commercial development of our country can hardly be over-estimated.

Attempts were made about 1870 to roll a combination rail with steel head and iron web and base, but the rapid reduction in price of all-steel rails rendered this process of no economic value, for while steel rails in 1872 sold for $140 per ton, in 1882 the price had dropped to $35 per ton. This cheaper production made possible the heavier rail of recent years, also the larger locomotives, greater capacity cars, and correspondingly greater economy in railroad operations. It is interesting to note in this connection that there seems to have been a fixed relation between the weight of rail in pounds per yard and the weight of locomotives in tons, for when we had 60 lb. rails in general use, we had 60 ton locomotives, and with the 100 lb. rail, came 100 ton locomotives; roughly speaking in 70 years the weight of rails has increased 70 lb. or 1 pound per year.

Not many years ago the designing of rail sections had become a fad. Most engineers were called upon to get up a new standard design and nearly all roads had their own standard sections. As a matter of record, the rail mills at one time had no less than 188 different patterns and 119 patterns of 37 different weights per yard. The situation was investigated by the American Society of Civil Engineers and in 1893, after more than three years deliberation, the Society reported upon standard sections for rail from 40 to 100 pounds varying in weight in 5 lb. increments. This report was accepted by the Society and recommended to the railroads for adoption during the year 1901. Rails of the above type of sections constituted fully 75 per cent of all the rails rolled in American mills.

In 1901 the report of the American Railway Association recommending the use of 33 ft. rails was adopted. In October 1907, a preliminary report was submitted accompanied by two series of proposed standard rail sections and in 1908 the report recommended types A and B. Since October 1907 several mills have rolled rails substantially in accord with the new sections, both A and B, and it has been demonstrated that these sections can be finished in the mill at a lower temperature than the A.S.C.E. sections. A finer grained and better wearing rail should be secured. However, great care must be exercised in the mills to see that the rails are actually rolled at the lower temperature.

During the year 1913 there has been laid on the Boston and Maine Railroad, 500 tons of 85 lb. frictionless rails in curves of $5\frac{1}{2}$ deg. and over, with which it is hoped to lessen materially the flange wear on high rails which on sharp curves is always considerable. Actual experiment shows that curve resistance is a great deal lessened by the use of this rail. The theory offered for the action of the so-called frictionless rail is based on the means that it offers the outer wheel on each axle to become dominant over the inner one, and the inner wheel to slide laterally to release the outer wheel flanges as they are forced against the outer rail. The outer wheel is traversing a greater distance through a curve than the inner one but is making the same number of revolutions. On this account, a compensating slide of the outer wheel or a spin of the inner one must occur. The frictionless rail allows this necessary spin to occur at the inside rail.

No subject concerned with track appliances has been more discussed than that of the joint fastening. The evolution of joint fastenings has advanced through three stages; first, the chair which maintains the ends of the rail in alignment and serves as a bearing; second, the fish plate which afforded the rail some support under the head but greatly improved the matter by stiffening the junction of the rails vertically, and third, the angle bar which combines the features of the fish plate and flange and effected a great improvement in both the vertical and horizontal stiffness of joint fastening; the plain angle bar is very simple, easily applied and cheap in first cost.

The conditions which bear some relation to the wear of splice bars are the extent of bearing surface and the hardness of the metal. In the new 85 lb. rails and smaller sizes, the question arises whether the plain angle bar meets with the ideal requirements of the splice bar in the two important respects, strength, and the wear in the immediate vicinity of the joint which

[1] Chief Engineer, Boston & Maine RR.

affects the close union of the parts. We know that angle bars are not strong enough because they bend and take a permanent set in service, and occasionally one breaks. The supported joints which we have had in use are the Fisher, the Continuous and the Weber joints.

For bolts to fasten the joints to the rails, the most efficient are those having the so-called grip thread. This bolt is made of a soft steel and the threads are cold pressed in a manner to upset the metal so as to reduce the diameter of the bolt but slightly at the bottom of the thread. The threads are ratchet shape and under cut 5 deg. on the bearing side. In the nut the bearing side of the thread is at right angles to the axis of the aperture, so that when it is screwed tight against the splice bar the threads of the bolt give to the extent of which they are undercut and the metal will be pushed completely to the outer recesses of the nut threads, so as to hold the nut against turning off. The nut is square with the corners chamfered next to the wearing surface which gives an approximately circular bearing. On the bearing side the nut is recessed the depth of a thread and to a diameter somewhat larger than that of the threaded bolt, thus housing and protecting the many threads against injury by the chafing on the splice bar.

The first tie-plates were used to prevent rails from cutting into and destroying the ties. Gradual development has added other features such as the top shoulder, spike hole, bottom claws and ribs, all tending to make the tie-plate not only a tie protection but a more valuable rail brace. Economy of material compels a minimum of weight consistent with strength and one of the most important considerations is to obtain a tie-plate which will unite firmly with the tie; otherwise it will pound the tie and wear it under rail vibration and afford no lateral resistance to the spreading of the rails. As such a requirement cannot be had by a plate with a smooth underside, practically all tie-plates are now made with under projections in the shape of claws which enter the wood crosswise of the grain or of the flanged or rib type which enter the wood longitudinally with the grain. In the former case the lateral displacement of the plate is resisted by an abutment against an end section of the fibres. The standard Boston and Maine tie-plate has four flanges which enter the grain of the tie longitudinally, running the width of the plate. The latest tie-plate shows the two longitudinal flanges and two smaller transverse flanges on the bottom, a heavier shoulder and a better portioning of material.

Wooden ties have been almost universally used by the railroads of this country and are still used as best practice. Steel ties and ties of concrete construction have been made and are used to some extent with varying success. For wooden ties, the hard wood tie of oak, chestnut and hard pine are used mostly for main line traffic and the softer woods such as cedar, for branch lines of light service. The standard Boston and Maine tie is 6 in. thick by 8 in. wide and 8 ft. long. The average life of a chestnut tie is seven years, and hard pine ties eleven years. The life of a tie can be lengthened by the use of tie-plates and preservatives.

I can see no radical change in the present track materials or methods in the immediate future. The rail may be heavier and more spikes, tie-plates and braces added, but the general design will be the same. The changes in turnouts and yards will be most marked; longer switch leads, wider spacings of track, heavier rail and more careful maintenance are already necessary in a great number of our yards due to the increased loads in power and rolling stock. In the Pennsylvania Terminal in New York City, we find part of the tracks laid on stone ballast and some part on a solid concrete base, with creosoted ties bedded therein and anchored by bolts to the concrete.

ELECTRICAL EQUIPMENT

By Frederic D. Hall,[1] Boston, Mass.

Non-Member

SYNOPSIS OF PAPER

The author showed slides illustrating types of later electric locomotives and the catenary construction for both A.C. and D.C. operation. The present slow growth should not be taken as a sign of lessened determination or activity. The installations already made for special requirements, while handling traffic in a manner impossible by steam, are short and disconnected, thereby not permitting realization of full economies. No statement that installations are other than successful can be regarded seriously, for railway managers are too conservative and too much occupied with detail required of them to listen readily to radically new methods of operation. The present attitude of manufacturers, each exploiting his own system, is confusing to railway men, and detrimental to their common interests; designing engineers are not very far apart in their convictions. A standardized system of distribution must be worked out before an argument strong enough to carry conviction can be presented, and the burden of proof must rest on the manufacturers. Railway managers are not fair in their consideration of electrification, since they compare the cost of an entire electrification with that of a few steam locomotives from time to time without sufficient regard for future requirements and without considering the various expensive changes in road bed, bridges, engine houses, turntables, new shops and tool equipments, etc., made necessary by the heavier power, not only a heavy capital charge but an ever increasing operating cost, not charged to cost of new locomotives but passed by merely as improvements to property.

[1] Elec. Engr., Boston & Maine RR.

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

The man who makes assumptions in engineering must expect to find that he is wrong, and the Engineering Survey of this month presents several illustrations of this fact: the working processes in a suction compressor taking air at an initial pressure above atmospheric are not as they were usually assumed to be; the action of gripping devices on elevators is different from what it was supposed to be; and the same is true to a certain extent with respect to the resistance of locomotives and operation of saturated steam locomotive boilers.

THIS MONTH'S ARTICLES

The article on the operation of suction compressors has been already mentioned above, as well as the investigation of grip devices. In the article on centrifugal pumps built by a German concern is described an interesting type of pump for mine work, particularly adapted to sinking shafts.

The railway engineering section contains an account of tests of a saturated steam twin express locomotive, in which the boiler and engine have been tested first separately, and then together as a unit. In another part of the same section is presented an extensive abstract of a series of Russian tests on the resistance of locomotives and cars while in motion and under various atmospheric conditions (it is the general rule of the Engineering Survey to make more extensive abstracts of articles published in little accessible publications, or languages not commonly known in this country).

A variation in the design of combined Cornwall tubular boilers is described in the Steam Engineering Section, the advantage of the type being its higher coefficient of safety and less necessity for skilled attendance. In the same section is described a rather unusual case of an explosion of a de Laval rotor caused apparently by some internal defect in the material which had not been previously discovered because no overspeed tests of the rotor were made by the manufacturers. R. Schulz shows that it is mainly the presence of oils in imperfectly cleaned water of condensation, used over again as feedwater, that causes corrosion in boilers, while separators for extracting oil from steam, as usually made, are far from being efficient enough to give an absolute guarantee of producing water of condensation safe to use in a boiler. Attention is called to the interesting experimental investigation of what is known as "knocking" in the crank mechanism of reciprocating engines, the main feature of which is that it is *experimentally* determined with a special apparatus which makes it possible to establish the causes of knocking with great completeness. The apparatus also lends itself to several other uses in connection with the investigation of machine parts having a motion different from one along closed continuous curves.

A communication of the German Royal Testing Laboratories at Gross Lichterfelde West describes a new method for the determination of heat conductivity of refractory materials, which avoids the well-known difficulties of the calorimetric method; the apparatus is simple and easily installed.

Richard H. Rice describes the operation of turbo-blowers for blast furnace blowing, and shows, by means of a specially designed apparatus, that, contrary to frequent contentions, the blast from a turbo-blower is actually more steady than that from a reciprocating engine.

From the Journal of the American Society of Naval Engineers are taken articles on the operation and trials of the U. S. Collier *Jupiter*, the construction of which has been described in a paper presented before this Society; and tests on the use of mixed oils in forced-lubrication systems which appear to establish that such a use of oils has no harmful effects. From the same source is also taken an empirical formula for the weight of steam passing through a venturi tube (a modified Rankine formula).

Data upon the new turbine pumps of the St. Louis Water Works, and a formula for capitalizing the investment, are presented in a paper before the Association of Engineering Societies. The Australasian Institute of Mining Engineers has a paper on the requirements of economical winding containing, among other things, an interesting list of safety devices which the author claims to be necessary in a winding engine as "the saving of property in the event of an accident more than compensates for their initial and maintenance costs." The principles of scale construction are summarized from the manuscript of a paper presented before the Eighth Annual Conference of Weights and Measures (very kindly loaned for this purpose by the author, Mr. A. Bousfield).

Professor Horace Judd, in a paper before the Ohio Society of Mechanical, Electrical and Steam Engineers, presents interesting data on the Taylor stoker operating under ordinary conditions.

Owing to lack of space several articles which would otherwise be reported in this issue, have been held until another issue.

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* e perimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

Air Machinery

Influence of the Suction Pressure of a Compressor on its Power Consumption and Output (*Der Einfluss der Saugspannung eines Kompressors auf dessen Kraftverbrauch und seine Ansaugeleistung*, Hans Wunderlich. *Die Fördertechnik*, vol. 7, no. 9, p. 105, May 1, 1914. 3 pp., 5 figs. *t*). There are still many erroneous ideas about the power consumption of compressors, working on gases having an initial pressure above the atmospheric, and there are even persons who still believe that the compressor working with such gas consumes less power than one handling gas at an initial atmospheric pressure. They do not consider the facts that the suction volume corresponding to various suction

pressures is not constant and that the heat relations in such a compressor are essentially different from those in a compressor which takes its supply at atmospheric pressure. In order to determine the power consumption of such a compressor, the author proceeds in two ways, first determining the theoretical power consumption by means of entropy diagrams, and then graphically.

Theoretical determination of power consumption of the compressor by means of entropy tables. In Fig. 1A *a b* represents the adiabatic curve and *a c* the isothermal. Further, the work of isothermal compression is represented by the area *a c d f* which is geometrically equal to the area *a c g h* representing the *P V* diagram in the present case. It comprises the work of compression and the work delivered at constant pressure. The value corresponding to both of these areas is (see Fig. 1B).

$$L_1 = \frac{(S_1 - S_2)T_1 G_s}{A} \text{ in kg.}$$

If the compression occurs adiabatically, which is nearer to what actually happens, then the area *a b e f* in Fig 1A represents the corresponding work; to this should be added the

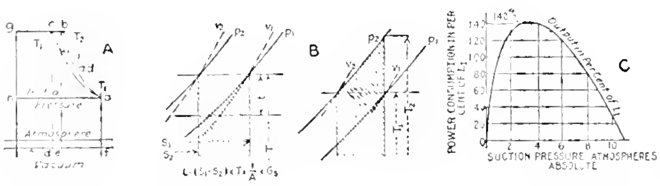

FIG. 1 DIAGRAMS OF THE WORKING OF A COMPRESSOR TAKING GAS AT AN INITIAL PRESSURE ABOVE ATMOSPHERE

strip *b c d e* representing the heat losses through radiation and conduction, due to the fact that the air or gas goes to the place of consumption without usefully employing the heat which it contained when it left the compressor. The area *a b e d f* represents therefore the total work consumed in adiabatic compression. Such work on the PV diagram being represented by the area *a b g h*, the value corresponding to it is

$$L_a = \frac{C_p(T_2 - T_1)G_s}{A} \text{ in kg.}$$

In order to obtain the number of horsepower for each case, one must divide the values of L_1 and L_a by 75, and this, with mechanical efficiency ϕ, will give the following expressions:

$$N_1 = \frac{L_1}{75\phi} \text{ and } N_e = \frac{L_a}{75\phi}$$

In the above formulae and figures, the following notation is used: A, the mechanical equivalent of heat, $\frac{1}{427}$ m/kg; S_1, S_2, entropy; C_p, specific heat at constant pressure; T_1, T_2, absolute temperatures; t_1, t_2, temperatures; G_s, weight of air taken in by the compressor per second; L, work generally; L_1, L_a, work under specific conditions; N_i, indicated horsepower; N_e, effective horsepower; ϕ, mechanical efficiency.

Graphical determination of power consumption. For this purpose one has to plot the PV diagram with the corresponding suction pressures and the required end pressure and evaluate it by means of a planimeter in order to establish thus the average diagram pressure *p m*. From this the work required for operating the compressor can be determined by means of the equation $L = 10{,}000\, F(pm)c = Pc$ and from this the indicated and effective horsepower consumption are derived respectively:

$$N_1 = Pc/75 \text{ and } N_e = Pc/75\phi$$

In this equation F is the area of the piston in square meters, pm the average diagram pressure in kg. per square meter, c piston velocity per second in meters, P power on the connecting rod in kg. For air at 16 deg. cent. (60.8 deg. fahr.) and an output of 1 kg. of air taken in per second, the above equation assumes the form $L = 8350\ pm$ in kg.

The author gives two examples of the application of this method of which the first will be reported here. Let the end pressure of an air compressor be 11 atmospheres absolute and be constant, while the suction pressure varies from 1 atmosphere to 2, 3, 4, etc., up to ten atmospheres, increasing by steps of one atmosphere each. The compression is in a single stage and proceeds on the purely adiabatic process, in accordance with the law, $pv^{1.41} = C$, the suction temperature is in all cases 16 deg. cent. or 60.8 deg. fahr., and the weight of air 1.2 kg. per cubic meter (0.74 lb. per cu. ft.). The work theoretically expended by the compressor per second is in accordance with the equation

$$L_a = cp\,(T_2 - T_1)427 G_s \text{ in kg.,}$$

where G_s is for simplicity's sake assumed, at atmospheric pressure, to be equal to one. The rise of temperature of the air which occurs in adiabatic compression is read off for each case directly from the entropy table. The specific heats vary slightly with the temperature but practically are not affected by high pressures.

$$C_p = 0.2259 + 0.0000394\,T \text{ and } c_v = 0.1574 + 0.0000394\,T$$

The compressor outputs at suction pressures from one to ten atmospheres absolute and final pressure of eleven atmospheres absolute are evaluated as follows: The last column of Table 2 is obtained by making $L_a l$ equal to 100 per cent. This shows the large influence of the suction pressure on the power consumption of a compressor. It appears that it is at its best between three and four atmospheres absolute and from there on rises by about 50 per cent. In Fig. 1C the output curve for this case is plotted and from it the power consumption in percentages of $L_a l$ can be read off directly. The author gives also the ten diagrams corresponding to each of these cases and derives the power consumption for each case from the diagrams. The two methods give practically identical results, but the determination from the entropy table is much easier and simpler. In practice it is quite often important to know which way of compression would prove more economical; for example, if it is necessary to compress a certain amount of air (say for testing purposes) to 225 atmospheres while the compressed air system of the shop has a pressure of only six or seven atmospheres, it is more economical to use a small single stage pump than an expensive two stage compressor. On a larger scale, the same considerations apply to the production of compressed air for mine locomotives. There quite high pressures, around 150 atmospheres, are used, and to produce them four and five stage compressors of about 320 h.p. are required. If the same compressor would receive the air from the compressed air system, i. e., previously compressed to six or seven atmospheres, one could eliminate at least one stage, which would be equivalent to a saving of about 80 h.p. The compressor would become simpler, power smaller and total costs of installation lower.

Hoisting Machinery

INVESTIGATION OF GRIP DEVICES ON ELEVATORS IN ACTUAL OPERATION (*Untersuchungen an Fangvorrichtungen im Betriebe befindlicher Aufzüge*, R. Mades. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 21, p. 827, May 23, 1914. 9 pp., 31 figs. e A). The present article covers investigations of grip devices on freight and passenger elevators. Most of the investigations made hitherto have been effected with an apparatus showing the retardation of the elevator by means of a spring and weight. In the present instance the process adopted was that of time-path diagrams because it was desired to investigate the motion of the grip wedges simultaneously with that of the elevator itself. This process led to the formation of new views with regard to the mode of operation of gripping devices. The diagrams were then subjected to a graphical process of estimation. The testing arrangement was such that both cage ropes or each one singly could be instantly released either while at rest or during the downward motion. The releasing device acted so suddenly that in the diagram no distinction could be discovered between the beginning of the theoretical curve of fall and the instant of release. The measuring device con-

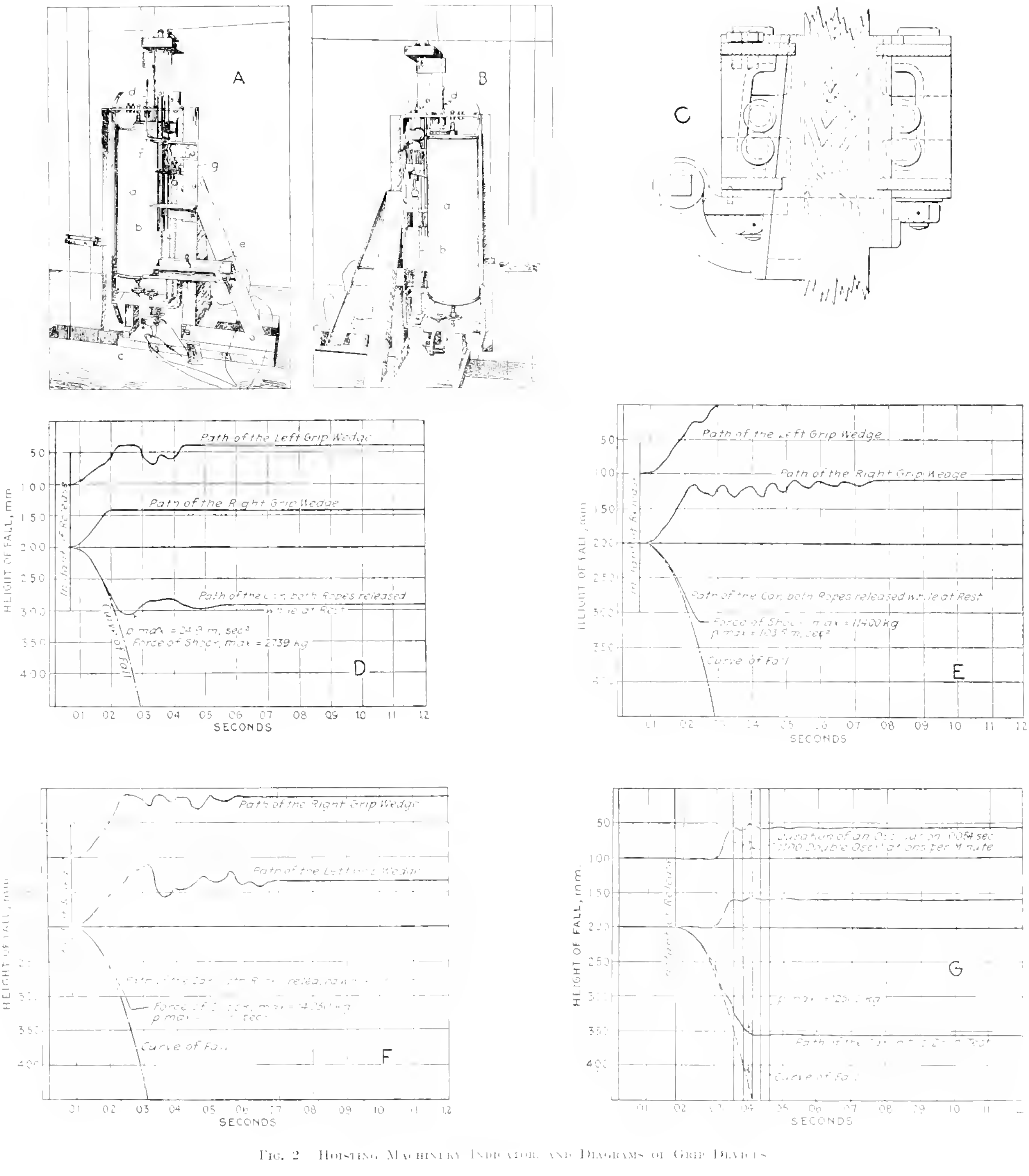

FIG. 2 HOISTING MACHINERY INDICATOR, AND DIAGRAMS OF GRIP DEVICES

sisted of a measuring drum *a*, Figs. 2A and B, 160 mm (6.4 in.) in diameter and 500 mm (19.6 in.) long with a diagram sheet 500 by 500 mm (19.6 x 19.6 in.) area. The drum was at first given an acceleration by means of a powerful spring *b*, and when it reached its highest angular velocity (after a rotation through 40 mm (1.57 in.) measured along the periphery), it was further rotated by a clock device provided with a brake governor *c* in such a manner as to maintain the angular velocity constant. The drum *a* makes one complete revolution and is uncoupled by means of the rope *a* a short time previously to the release of the car. The time of revolution is usually set at one second since, in addition to the gripping process which lasts about 0.2 seconds, there are subsequent phenomena which take up the rest of the time up to one second. This time is measured by means of a calibrated tuning fork *e*, giving 100 double oscillations in one second. The diagram is traced directly on paper. There were also recorded the instant of the release *f* and the motion of both grip wedges *g*. The tests were made with wedges mounted on springs and provided with rolls, Fig. 2C, in such a manner that one rope was released when in the state of rest, first with an empty elevator and then with gradually increasing loads; next, the same test was made during the downward run at normal velocity.

The diagram D shows that the elevator has a free fall up to about 50 mm and from there on begins an irregularity of the curve of fall and consequently some sort of braking. It was established by graphical methods that there is a maximum retardation of 24.9 meters (81.6 ft.) per second per second, when the weight of the elevator proper is 1100 kg (2420 lb.) and no excess load applied. The diagram shows further that after the elevator came to rest, it jumped up 24 mm (say 1 in.) and then after a period of 0.48 seconds came to rest with an average travel of fall of 92 mm (3.62 in.). It was found further that the elevator was thrown upward through the elastic action of the compressed guides and that this upward jump was facilitated through the presence of rolls on the reverse side of the grip wedges. In a a second test the elevator showed a maximum travel of fall 115 mm with a retardation of 103.5 meters (339.48 ft.) per second per second, and a force of 1140 kg (2508 lb.). The elevator was gripped at exactly the same spot as in the first case. The increase of the shock taken up by the two guides appears to be due to the fact that during the first test the guides were strongly compressed at the place of grip and during the second test did not possess the same amount of elasticity. The motions of the grip wedges show that the latter had not come to rest when the elevator was already at rest (compare Fig. 2E). During the third test the maximum retardation rose to 128 m (419.8 ft.) per second per second and the force of shock to 14,050 kg (30,974 lb.). The motions of the grip wedges were still more violent than in the second test while the rise of the force of shock was less than in the second test, which indicates that the guides were compressed nearly to the limit (the gripping was executed always at the same spot, Fig. 2F). Further diagrams show that the shocks and motions of the grip wedges become more and more violent and since they are very irregular in their action, the elevator assumed more and more of a pendular motion and struck against the guides from which it was violently repulsed. If a resonance should occur between the pendular motion of the elevator and the oscillations on the guides, while the motions of the grip wedges should come into synchronism, complicated processes would take place (this may easily happen because the grip wedges are of similar construction and equal weight). The diagram in Fig. 2G shows that the possibility of the motions of the grip wedges being in synchronism, is by no means excluded, and when this happens, the knocks are sometimes so violent that the pencil jumps out of its holder on the drum even though it is held there by a stiff spring.

The author points out that the usual tests do not fully guarantee the safety of operation of elevators as they do not establish the possible weakening of the guides due to the gripping and the loss of friction in the grip wedges due to the roughened face of the wedge being filled up by particles of wood. He recommends therefore a series of tests which would comprise: a release of a single carrying rope, first with no load and then with gradually increasing loads; release from rest of both carrying ropes, first with no load and then with gradually increasing loads; release of a single rope during the downward run at normal velocity, first with no load and then with gradually increasing loads, and a similar release of both ropes. At the same time proper tests should be made to establish at each velocity—whether the governor sets into operation the gripping device and whether it is done in a proper manner. The article contains further tests showing among other things the comparison between grip wedges mounted on springs and working without springs and also the general action of such wedges. In the tests made with passenger elevators, it was also shown that there is a violent jumping of the grips. The author shows the braking follows not, as was hitherto assumed, a parabolic curve, but acts intermittently, in shocks.

Hydraulics

Influence of a Coat of Inert Oil over the Inside of Cement Pipes on the Resistance to the Flow of Water Through the Pipe (*Einfluss des Innenanstrichs von Zementeohren mit Inertol auf die Grösse des Leitungswiderstandes, den Wasser beim Fliessen in Zementeohren findet*, R. Stückle. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 20, p. 796, May 16, 1914. 2 pp., 7 figs). The Paul Lechler Company of Stuttgart, Germany, made quite an extensive series of tests to determine the influence of a paint of inert oil on the flow of liquid in a cement pipe. This was done by comparing the flow of water through a pipe, the surface of which in one series of tests remained rough and in another was covered with a paint of inert oil. The pipe, having a gradient of 231.5 mm. in a length of 15.236 m., was laid for 20 m. (65.6 ft.) and had an average opening diameter of 148 mm. (say 6 in.). It consisted of twenty pieces each one meter long, carefully connected with one another, and the joints filled with cement and thoroughly smoothed. At one end of the cement pipe was added a cast iron pipe about 2 m. (6.5 ft.) long and the same diameter as the cement pipe. At the other end was a connection with a water tank, arranged in such a manner as to permit a constant pressure head, which might vary from one test to another. In all tests the water came out from the piping through a long sweep bend either into a measuring tank or at a free out-flow. In the second series of tests the same conditions were maintained, but the inside of the pipe was covered by a paint of inert oil. The article gives full data of the test. From the results obtained it appears that the

coefficient of resistance, determined from the usual equation given below, decreases for increasing velocities of flow when the latter vary from 0.63 to 1.69 m. per second; but in the case of the pipe covered by a paint of inert oil it is generally smaller than in the rough pipe and decreases more rapidly with increasing velocity of flow, the difference of its value in favor of the oil-painted pipe being 2.5 per cent for a velocity of flow of 0.659 m. per second to 7.1 per cent for a velocity of flow of about 1.69 m. per second. The author gives a diagram where the values of both coefficients of resistance are plotted with water velocities as abscissae and resistances as ordinates. The values of the coefficient of resistance for rough pipes appear to lie in a practically straight line while those for the oil-painted pipe appear to have a considerably greater curvature.

The equation referred to above is as follows:

$$X = h \frac{d}{l} \frac{2g}{c^2}$$

where d = inside diameter of pipe in meters, l — length of pipe in meters, c = velocity of flow of water in the pipe in m/sec., g = 9.81 m/sec. and h = loss of head in meters.

Centrifugal Pumps of the Maffei-Schwartzkopff Company in Berlin (*Der Kreiselpumpenbau der Maffei-Schwartzkopff-Werke G. m. b. H., Berlin*, R. Schnabel. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 20, p. 769, May 16, 1914. 10 pp., 53 figs. *d*). The company builds two main types of pumps of the high-pressure type where large heads of delivery have to be handled. The type preferably selected is that with an undivided cylindrical casing: its advantage, especially for operation in mines, consists in the fact that the pump may be dismantled without lifting the casing from the plate. In the other type, which is used mainly, though not exclusively, for small delivery heads, the pump is divided into several sections vertically in accordance with the number of stages, the separate parts of the casing being held together by threaded bolts. The shape of the rotor and distributor blades which determine the output of the pump and its efficiency are in their main characteristics the same for both types. The suction standpipe is located at the side of the coupling in order to preserve the accessibility of the automatic balancing device on the pressure side. All parts inside the pump which have to be provided with packing between two spaces of different pressures, such as the rings at the entrance of the wheels, the bushes between stationary and rotating parts and so on, are made of appropriate alloys, which under ordinary circumstances show practically no wear. Special attention was paid to the production of a device for compensating the axial thrust which would work reliably under all conditions, a fundamental requirement for the operation of a high-pressure centrifugal pump. This device consists of a piston which constantly tends to move the shaft in a direction opposite to the axial thrust, and a vertical throttling disk which regulates the pressure of the fluid acting on the piston and in this way takes up, in an entirely automatic way, the forces constantly acting in the direction of the suction side. In addition to that, the outer end of the piston carries another disk for the balancing of the sleeve. This latter device first comes into action when the piston has undergone a large amount of wear and in this case takes up the axial thrust also.

Apart from the sleeve balancing, which, however, seldom comes into action, the two types of pumps differ with respect to the balancing of the axial thrust only by the location of the throttling disk in front or behind the piston, of which the water leak is further used for cooling the bearings. Since there is little pressure behind the piston, it is quite sufficient to use a soft cotton packing for the stuffing box and a similar packing also on the suction side. In order, however, that no air shall pass through the stuffing-boxes, they are connected with a water chamber, the water of which

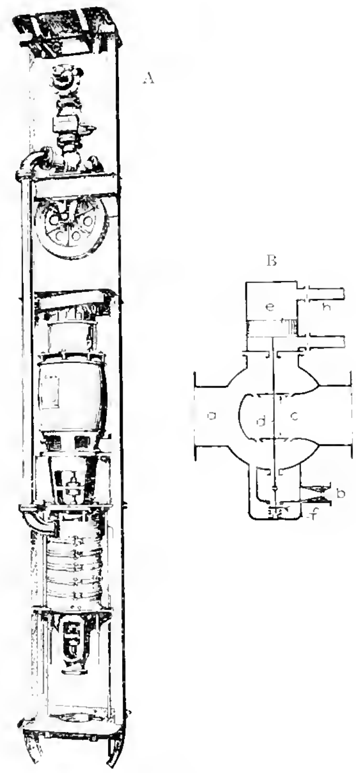

Fig. 3 Maffei-Schwarzkopff Mine Shaft Pump and Pressure-Output Regulator

as a rule is brought in from the first stage of the pressure line.

In considering the two types of pumps, it might be supposed that in the pump with undivided casing, the design of the internal parts would be made more difficult through the possibility of their being affected by handling water with the tendency to form hard deposits, but as a matter of fact no such a thing occurs. The cast iron intermediate parts are covered on the outside with bronze rings, provided with passages into which kerosene is forced from the outside by means of a small hand pump and the casing may have a bronze jacket to protect it against electrolytic action.

The article describes and illustrates various types of pumps driven electrically and by steam turbines. A special type for handling various delivery heads is shown in Fig. 3A and is used for mine work. Since only a part of the cross-section of the mine shaft is available for locating the pump, the latter, together with its motor, are placed vertically in a wrought iron frame provided in the upper part with the rope drum and a rope by means of which it is gradually lowered, as the bottom of the shaft is sunk deeper. The general construction of this pump does not

materially differ from stationary horizontal pumps, but in order to obtain large suction heads and a simple method of water delivery, the suction standpipe is located at the lowest point near the motor on the pressure side. The bearings are finished with particular care and their lubricating oil moves automatically in a closed circuit. The cut-off slide valve is regulated either by hand or by means of a chain and makes it possible to set the pump for a desired amount of delivery.

In order that the pump shall work economically, even at small depths, it is often provided with only part of the stages necessary for the greater depth, the intermediate spaces being filled up with so-called "blind pieces" which, as the depth increases, are gradually replaced by rotors and distributors. The pump body is so constructed that this change may be effected in a short time in the shaft itself. When high-pressure centrifugal pumps are used in mines for pumping against high heads it must be borne in mind that the output varies materially from time to time and adjustment for this may be very simply effected by limiting the upward stroke of the pressure water collector, without having to change the speed of rotation. When the volume of discharge decreases and the pump is working against constant pressure, the collector lifts until it reaches the upper limit. Then the pressure in the piping system rises and thus produces a reduction in the output. If the drawing-off of water ceases entirely, the pump works with cut-off valve closed, but it is not advisable to permit a pump to run for a long time in dead water since the heating of the water might easily injure the internal parts of the pump and it is much better to install a valve governed by the pressure of the water in the collector in such a manner that when no water is drawn off, it would automatically permit enough water to flow into the suction piping or into the well as would prevent any injury to the pump. Such a device is shown in Fig. 3B. It consists of a passage valve casing *a* made of cast iron or steel casting, installed in the pressure piping between the pipe and the collector and provided with an outlet opening *b* for the no-load water. The spindle *d* of a double beat drop valve *c*, carries on top a piston *e* and extends downwards far enough to be able to push off the no-load valve *f*. Two extensions to the pressure water collector permit a small piston not shown in the drawing to move up and down in such a manner that the pressure water may enter either below or above the piston *e*. When the collector reaches its upper level, the pressure water enters through the pipe *h* from above the piston, closes the double beat drop valve and opens the no-load valve. The water delivered by the pump flows off through the throttling nozzle *b*, and the upper consumption decreases to about one half. If pressure water is drawn off and the level in the pressure water collector sinks, the steering piston permits pressure water to enter from below the piston and as a result the double drop valve rises, the no-load valve, under the action of a spring, automatically closes, and the pump begins again to deliver water into the collector (working thus at full output).

Internal-Combustion Engines

Horsepower Formula for Automobile Engines (*Leistungsformel für Automobilmotoren*, A. G. von Loewe. *Der Motorwagen*, vol. 17, no. 13, p. 289, May 10, 1914. 1½ pp. *pm*). The author derives the horsepower formula without introducing the factor p_i (average piston pressure), and obtains the following expression:

$$N = a \cdot \frac{i n}{2 \times 75 \times 60} \text{ horsepower}$$

where

$$a = \frac{1 - \frac{1}{\varepsilon^{k-1}}}{k-1} \cdot \frac{\pi d^2 s}{4} \cdot \frac{H}{T_a C_{vm}(L+1)}$$

and N is the theoretical horsepower of the motor; i the number of cylinders; a the work of the motor during its four cycles; n the number of revolutions per minute; d, cylinder bore; s, stroke; $k = c$, ratio of specific heats of the mixture, c_p at constant pressure, and c_v at constant volume; ε, compression ratio (ratio of the volume of gas at the beginning to that at the end of the compression stroke); H, heating value of the fuel (kilogram of gasoline); T_a, absolute temperature at the beginning of the compression stroke; C_{vm}, average specific heat of the mixture at constant volume; L, weight of air required for the combustion of 1 kg. of gasoline (all the quantities in standard continental values).

To obtain the effective horsepower, the value of N will have to be multiplied by a coefficient of efficiency η_e and, since in the derivation of his formula the author started not from the mechanical equivalent of heat, but from the rise of temperature at the instant of explosion, he uses the theoretical thermal coefficient of efficiency $\eta_t = 1 - \varepsilon^{1-k}$, and the efficiency of the engine is expressed as $\eta_e = \eta_g \cdot \eta_m$, where η_g is the quality factor and η_m mechanical efficiency of the engine.

This leads to the final formula for the effective horsepower:

$$N_e = \left(\frac{1 - \frac{1}{\varepsilon^{k-1}}}{k-1} \right) \cdot \frac{\pi d^2 s}{4} \cdot \frac{H}{T_a C_{vm}(L+1)} \cdot \frac{i_1 n}{9000} \eta_e$$

$$= B \frac{\pi d^2 s}{4} \cdot \frac{H}{T_a C_{vm}(L+1)} \cdot \frac{i_1 n}{9000} \cdot \eta_e$$

where $B = \dfrac{1 - \frac{1}{\varepsilon^{k-1}}}{k-1}$

The values of H, T_a, C_{vm}, and L are either given, or can be easily determined by actual measurement; the efficiency η_e may be also assumed to be known; k may be assumed to be known, and the author gives a table for values of B corresponding to certain values of ε, under the assumption that $k = 1.3$.

Assume a four-stroke cycle engine, which has $d = 10.0$; $s = 0.17$; $\varepsilon = 4.8$; $n = 1600$. Then

$$N_e = 1.250 \times 20.4 \times 0.00135 \times 1600 = 55.08 \text{ h.p.}$$

Railway Engines

Tests of a Wet Steam Twin Express Locomotive (*Versuche an einer Nassdampf-Zwillings-Schnellzuglokomotive*, R. Sanzin, *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 22, p. 858, May 30, 1914. 6 pp., 8 figs. *e*). The interest of the tests reported in the present articles lies in the fact that they were first made on the boiler without regard to the engine, next on the engine as such, and finally on the locomotive as a unit, comprising both boiler and engine. The type of locomotives tested was introduced about the year of 1901 and the investigation covers numerous tests on locomotives used for passenger and express traffic on the Southern Railway in Austria.

Table 1 gives the data obtained from the tests of locomotive boilers and in the original article is supplemented by several diagrams. As a basis for the investigation of the processes of combustion and evaporation, there was considered the rate of combustion or the amount of coal burned per unit area of grate per unit of time, which, in kg. per hour per square meter of grate area, corresponds to the amount of fuel in the table indicated by $\frac{B}{R}$. For the determination of the value of $\frac{B}{R}$ only the time was considered during which the throttle was open, as it was found that when the throttle was closed very small amounts of coal were burned, owing to lack of draft. The present investigation was carried out with a grate duty of 200 to 600 kg qm per hour. With smaller amounts of coal burned on the grate the output of the locomotive was so small that it could scarcely be regarded as continuous operation, and while on the other hand a somewhat higher rate of combustion, up to 650 kg qm, could be obtained with expert firing, a maximum grate duty of 500 to 550 kg qm was obtained as an average. The coal was rich in gas, giving a long flame. Its comparatively low heat value (6250 WE) (11,250 B.t.u.) was compensated for by a high rate of combustion. The coefficient of evaporation $\frac{D}{B}$ corresponds to a boiler pressure (gage) of 12.5 atmospheres and temperature of feed water of 10 deg. cent. or 50 deg. fahr. With an average heating value of coal of 6250 WE (11,250 B.t.u.) and a consumption of heat of 655 WE per kg. (1179 B.t.u. per lb.) of steam, a theoretical coefficient of evaporation of 9.55 was obtained, but the actual coefficient of evaporation varied from 8.00 to 5.59 with the amount of coal burned per 1 qm (from 200 to 600), and with the increase of the grate duty, decreased at first rapidly and then more gradually. The variation of the coefficient of evaporation is of great value for the estimation of the fuel, but of course is affected by the kind of firing. The amount of steam $\frac{D}{H}$ generated per 1 qm of heating surface per hour increased with the amount of coal burned per hour but not in a straight line ratio, as $\frac{D}{H}$ remains somewhat behind the growth of $\frac{B}{R}$ owing to the decrease in the coefficient of evaporation, so that, while the amount of coal burned per 1 qm of grate area rose from 200 to 600 kg or increased three-fold, the evaporation per 1 qm of the heating surface increased only from 31.3 to 65.5 kg or 2.09 times. It is, therefore, of advantage to use instead of $\frac{D}{H}$, the value of steam generated per 1 qm of grate area per hour, or $\frac{D}{R}$, since it is not so subject to variations and therefore better permits of comparing various kinds of locomotives.

As regards coal test runs, the author, in addition to the usual measurements of the coal consumed and water evaporated, also measured the rarefaction of air in the smoke box, fire box and ashpan and the temperature of the smoke box gases. The advantages which these simple measurements afforded for the investigation of the process of combustion, proved to be so great that further steps were taken and gases of combustion were analyzed which made it possible to establish a heat balance and gave a clear insight into the processes of combustion.

In the four last columns of Table 1 and in Fig. 4, A is given the distribution of heat in the locomotive boiler for various amounts of coal consumed per unit of grate area, the heat value of the fuel burnt being used as a basis of calculation. During the tests, rarefaction of the air in the smoke box was measured both above and below the spark net as well as in the fire box and ashpan. The average rarefaction of air in the smoke box h and the fire box h_1 are

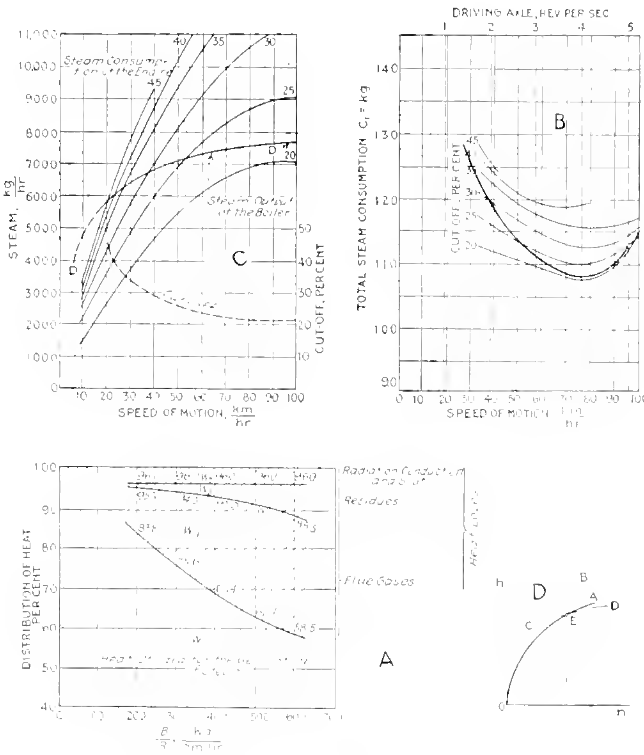

Fig. 4 Heat Distribution and Blast Pipe Operation, Locomotive Boiler

given in Table 1. It appears that h stands in a very simple functional relation to $\frac{B}{R}$ since the values of h obtained in the present test correspond with fair precision to the equation

$$h = 0.00655 \left(\frac{B}{R}\right)^2$$

The following notation is used: for boiler pressure p, for average pressure in the slide-valve chest p_1, pressure at the beginning of admission p_2, at the beginning of expansion p_3, at the beginning of exhaust lead p_4, at the end of the piston stroke p_5, lowest pressure during exhaust p_6, pressure at the beginning of compression p_7, and average effective pressure in the steam cylinder p_i. All the indicator diagrams used in this investigation have been taken with the throttle opened 0.8 of its maximum area, that is $0.8 \times 60 = 48$ qcm. (7.4 sq. in.), as it has been found previously that this opening of the throttle gives the most favorable results and further that no water is carried over into the steam cylinder, while on the other hand the fall of pressure produced thereby between the boiler and the slide-valve chest had no undesirable consequences. The boiler pressure was approximately 12.5 atmospheres, while the

blast pipe was set at its maximum cross section. Since the average useful steam pressure is materially dependent on the boiler pressure, it is worth while to use for its estimation, the ratio $\frac{p_i}{p}$, as this magnitude scarcely undergoes any variation as long as the boiler pressure varies within moderate limits.

The pressure in the steam cylinder during the admission falls off at first slowly and then rapidly. With small admissions the pressure lines during the inflow of steam can be represented with fair approximation by a straight line connecting the pressure p_i with p_a. In this case the initial pressure during admission is p_o and is equal to the average pressure in the slide valve chest p_i. It is especially important to know the value of $\frac{p_o - p_a}{p_o}$ for the design of steam pressure diagrams since it permits not only to establish the exact beginning of the expansion line but also enables to determine the amount of steam actually required during the admission to the steam cylinder.

The influence of the variation of the cross-section of the blast pipe on the back pressure was also investigated in the locomotives under test. The back pressure p_t when the maximum cross-section of the blast pipe of 160 qcm and thirty per cent admission was used amounted, even at five revolutions of the driving axle, to only 0.60 atmospheres, while with a cross-section of the blast pipe of 75 qcm it rose to 1.50 atmospheres with a corresponding material increase in loss of power. During the present test it proved possible on certain runs to test the locomotive with a certain constant cut-off and a speed of run as far as possible unvariable, so that the values for the water consumption after deduction of all losses could be used for the determination of the total steam consumption per indicated horsepower hour (these tests are to be taken with regard to the most usual average cut-off and average speed of rotation). The results of these tests are shown in Fig. 4B. Further the useful steam consumption was determined also from the indicator diagrams, and the difference between these two values for steam consumption shows the steam losses through condensation during admission and through leaks. The curves in Fig. 4C show the steam consumption for various degrees of admission and speed of rotation. If on the same diagram were plotted the curves showing the generation of steam in the boiler, it would give a complete picture of the way the boiler and engine work together.

Finally the total performance of the locomotives was tested, mainly in order to determine its maximum, this being the fact of greatest interest for practical operation. To do this the boiler has to generate the maximum amount of steam that it can do in a continuous run and this steam must be taken care of in the most favorable way by the engine so as to obtain the largest possible amount of indicated power. It has been already explained that the ability to generate steam on the part of the locomotive boiler when a given kind of coal is used depends, practically exclusively, on the draft available. During the run on a given section of the road and for a given amount of steam flowing through a given cross-section of the blast pipe per unit of time, the draft produced depends directly on the number of revolutions of the driving axle; the increase in suction with the increase of speed of rotation of the driving axle is at first rapid, then slower and apparently approaches a certain maximum value, the draft being also for the same amount of steam flowing dependent on the operation of the steering gear, that is beginning of the exhaust lead, shape and diameter of the outflow pipes, etc. The draft under certain conditions produces a certain amount of steam, but may not be able to do it under different conditions. This fact can be well seen when the draft is observed with the same cut-off but variable speed of run. In Fig. 4D the rarefaction of the air in the smoke box for the same admission but different speeds of rotation is represented by the line OA. In order to maintain this admission, amounts of steam increasing together with the speed of rotation are necessary, and to generate such amounts of steam certain minimum rarefactions of air in the smoke box are necessary and are represented in Fig. 4D by the line OB. The lines OA and OB intersect in point E, which shows that at this speed of rotation the draft required corresponds to the one actually available. For lower speeds of rotation the rarefaction in the smoke box is larger than necessary, while for high speeds it is evidently below that required. These conditions hold for all admissions and there is a certain geometric locus of points of intersection of all required and all actually available rarefactions of air CD, corresponding to the maximum output of the locomotive while in state of continuous operation. From these data on the rarefaction of air in the smoke box and the data contained in Table 1 can be determined the corresponding amounts of coal burned per hour per unit grate area together with the amounts of steam generated in the boiler per hour, and in Fig. 4C the line D shows the total steam generated per hour. This permits to gain a clear insight into the working together of the boiler and steam engine. It shows that with an increase of the speed of rotation the cut-offs one after another intersect the line of steam generation, and this in its turn shows that when such cut-offs are used, the amount of steam generated by the boiler is at first not fully taken care of, then at a certain speed of rotation, the total steam delivered by the boiler is used, and finally at a still greater speed, the boiler is pumped dry. The maximum admissions which are required for the highest outputs are indicated by the points of intersection of the steam consumption and steam generation curves. From these data in Fig. 4C the admissions necessary for obtaining the highest output of the plant can be derived, and it appears that at low speeds of rotation the cut-offs have to be varied rapidly and strongly while at higher speeds only little alteration is required.

TESTS (1912-1913) ON THE RESISTANCE OF PASSENGER LOCOMOTIVES AND CARS ON THE RUSSIAN RAILWAY SYSTEM (*Opyty 1912-1913 g. g. nad sapratirleniem passajirskikh pararozoff i ragonoff russkoy seti*, G. V. Lebedeff. ***Bulletin of the Permanent Committee of the Conferences of Agents of Various Branches of Service on the Russian Railroads*** (in Russian), no. 3, March 1914, p. 192. 22 pp., 9 figs. *eA*). In tests on the resistance of locomotives and cars which are now being made on the Russian railroads, the main basis for determining the power of a locomotive is the traction on the rim of the driving wheel. Actually, however, during test runs it is impossible to measure directly the traction on the rim of the wheel and it must be obtained either by calculation or from the formula:

$$F_k = F_t - W_m,$$

TABLE 1 LOCOMOTIVE BOILER PERFORMANCES

Coal burned per unit of grate area per hour $\frac{B}{R}$ Kg. qm.hr	Coal burned per hour B Kg. hr.	Steam generated per hour D Kg. hr.	Actual coefficient of evaporation $\frac{D}{B}$	Steam generated per unit area of heating surface per hour $\frac{D}{H}$ Kg./qm.hr	Steam generated per unit of grate area per hour $\frac{D}{R}$ Kg. qm.hr	Draft: Smoke box above spark net h (mm. of water)	Draft: Fire box h_2 (mm. of water)	Average temperature of flue gases $T-t$ deg. cent	Heat distribution, in per cent: Losses through flue gases W_1	Losses through residues W_2	Losses through radiation, conduction and soot W_3	Heat utilized for steam generation W
200	466	3728	8.00	31.3	1600	22	7	190	11.5	0.7	4.0	83.8
250	583	4425	7.59	37.1	1898	34	11	250	15.3	1.1	4.0	79.5
300	699	5047	7.22	42.3	2166	50	16	300	18.7	1.7	4.0	75.6
350	816	5614	6.88	47.1	2409	67	22	350	21.8	2.1	4.0	72.0
400	932	6086	6.53	51.0	2612	90	29	390	24.6	3.0	4.0	68.1
450	1049	6567	6.26	55.1	2818	111	38	415	26.8	3.8	4.0	65.5
500	1165	6978	5.99	58.5	2995	138	48	440	28.4	4.9	4.0	62.7
550	1382	7397	5.77	62.9	3175	166	60	453	29.4	6.1	4.0	60.4
600	1398	7813	5.59	65.5	3354	198	75	460	30.0	7.5	4.0	58.5

where W_m is the resistance of the locomotive as an engine; or else from the formula

$$F_k = F_n + W_v + \frac{P}{g}(1+\gamma)\frac{dV}{dt}$$

where W_v is the resistance of the locomotive as a carriage, P the weight of the locomotive with its tender, γ correction member for the rotating mass, V speed and t time. Since, however, W_m cannot be measured directly, only the second formula can be used for the determination of F_k, but to use it it is necessary to know W_v and $\frac{dV}{dt}$. There is no convenient apparatus for the determination of the acceleration of a train, the apparatus of Desdouits being too rough. Professor Lomonossoff, who is in charge of these tests, has therefore proposed to eliminate from this equation the multiplier of P in the last member, by means of the equation of the motion of cars:

$$Q\frac{1+\gamma}{g}\frac{dV}{dt} = F_n - W_n$$

where Q is the weight of the cars and W_n their resistance. This brings us to the formula of the traction on the rim as

$$F_k = \frac{P+Q}{Q}F_n + P(w_v - w_n)$$

where $w_v = \frac{W_v}{P}$ is the specific resistance of the locomotive as a carriage, and $w_n = \frac{W_n}{Q}$ is the specific resistance of the cars. F_n is determined by means of a dynamometer, while w_v and w_n have to be determined by separate tests.

The resistance of W_v of the locomotive as a carriage can be separated into two parts: The resistance of the locomotive carriage proper W'_v and the frontal resistance W'' of the air medium through which the locomotive has to make a passage for itself. As to the latter it is known that $W'' = \alpha\,\Omega\,V^2$ where Ω is the frontal surface of the locomotive and α is a coefficient determined experimentally and equal, according to the tests of Frank and Eiffel, to 0.006.

The determination of the resistance of a locomotive as a carriage was effected in two ways. The first and simplest was as follows: The train of several locomotives of a given type with the connecting rods taken off, was made up with a dynamometer car in front of the locomotives and connected with them by the dynamometer hook. Several test runs were made. The values of F_n read off on the dynamometer represent the sum of all W_v for all the locomotives *after the speed has become normal.* By dividing these readings by the number of locomotives or their total weight, we obtain the total or specific resistance of a single locomotive at various velocities, the frontal resistance of the air being evaluated in accordance with the formula given above. This method is very simple and convenient when conditions favor its application, but, in order that it should give reliable results, at least two or three locomotives of the given type have to be available, since the dynamometer readings are not reliable for small values of F_n. When only one locomotive of the given type is available, the other method, suggested first by Desdouits, had to be resorted to, namely, letting the locomotive run down an incline.

The theoretical basis of this method is as follows: The equation of the motion of a locomotive with the connecting rods taken off and moving down an incline is

$$\frac{P}{g}(1+\gamma)\frac{dV}{dt} = Pi + W_v$$

where i is the incline in mils. This formula may be converted into

$$\frac{dV}{dt} = \xi(i - w_v)$$

where w_v is the *total specific* resistance of a locomotive as a carriage and $\xi = \frac{2}{1000(1+\gamma)} \cong 120$, from which formula the expression for w_v is $i = \frac{1}{\xi}\frac{dV}{dt}$, which permits the determination of w_v if the incline and acceleration of the motion of the locomotive are known. Now assume that we have a section of the track of a known profile and that the locomotive travels by inertia, having previously received a certain initial velocity. At predetermined points of this section, at equal distances from one another, the time and velocity are recorded. If we assume further that between two points, sufficiently close to one another, the acceleration remains constant, it will be equal to

$$\frac{dV}{dt} = i - \frac{V_2 - V_1}{t_2 - t_1}\cdot\frac{3600}{g}$$

if time is expressed in seconds and velocity and acceleration

in kilometers and hours. Substituting this value of the acceleration into the previous equation and assuming a coefficient ξ = 120 (this coefficient varies very little for different locomotives), we obtain

$$W = i \quad \frac{1}{t_2} \quad \frac{1}{t_1} \cdot 30$$

which gives the specific resistance at any desired point of the road. Having performed several tests of running down an incline and referring each time w to the average velocity on the given section, we shall obtain a sufficient number of points to draw a smooth curve. The exactness of the results will depend, of course, on the precision of the measurement of time and speed. Initially the tests were performed in the following manner: A section about a mile and a quarter long of uniform, carefully leveled profile (i = —6) was selected and along it were placed posts 700 ft. from one another. The test locomotive with the connecting rods taken off was hooked to a dynamometer car, the resistance of which was previously determined. The car was used because it had an electric speed indicator giving instantaneous velocities. Behind the car was a second locomotive, not hooked up to the system, was used to drive the test train up to the first signal post where it was taken off. At the passage in front of each signal post, at the sound of a bell on the locomotive, the velocity was read in the dynamometer car from the electric indicator and the time from a stop-watch. It has been, however, found that this method is not suitable because the velocity was not measured with sufficient precision, while the time could be measured with an exactness up to a tenth part of a second. The method was therefore arranged as follows: each section of 700 ft. was divided into two and the time was read on the passage of the intermediary posts. Since at great speeds it was very difficult to notice the passage of each post, 350 ft. distant from its neighbor, only the time of the odd numbered posts were read, the time curves were plotted on a large scale as functions of the distance and the time of the passage of the even numbered posts was determined from these curves, which further permitted the rejection of erroneous observations. The velocity at each n th post was determined from the formula

$$v_n = \frac{S_{n+1} - S_{n-1}}{t_{n+1} - t_{n-1}}$$

In this case the dynamometer car is not necessary and the determination of the time can be made with greater precision because the observer does not read the time by the bell, but himself sees the signal post and presses the button of the stop-watch on the passage of each, while another man takes down the readings. The great convenience of this method of determining velocities lies in the fact that only one variable, time, has to be observed, which makes the observation easier and naturally raises the reliability of the results. However exact and sensitive a speed indicator may be, when it is used, it is extremely important to have its readings and those of the stop-watch taken simultaneously with the passage of the signal post, and in practice it is very difficult to obtain a perfect synchronization of these three moments. To determine acceleration at velocities above 50 km. per hour, sections of 700 ft. each prove to be too small. The calculations were therefore made by determining the velocity at the first and last sections and by assuming the acceleration on the entire run to be constant.

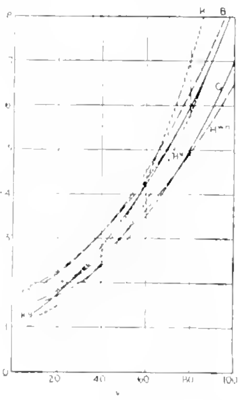

FIG. 5 LOCOMOTIVE RESISTANCES, RUSSIAN TESTS

TABLE 2 OUTPUTS OF THE COMPRESSOR WHEN TAKING AIR AT VARIOUS INITIAL PRESSURES

L_a	Equal to	in kg per sec	Per Cent
I	0.246 x 258 x 427 x 1	27000	100
II	0.2435 x 170 x 427 x 2	35500	131
III	0.242 x 125 x 447 x 3	38800	144
IV	0.2385 x 93 x 427 x 4	38000	140
V	0.2385 x 71 x 427 x 5	36200	135
VI	0.2385 x 54 x 427 x 6	33000	122
VII	0.2385 x 40 x 427 x 7	28700	106
VIII	0.2385 x 27 x 427 x 8	22000	81
IX	0.2385 x 17 x 427 x 9	15600	58
X	0.2385 x 8 x 427 x 10	8150	30

This assumption appears to be fully legitimate since the points along the curve lay even better than when the acceleration was determined for every 700 ft. Desdouits also made such an assumption.

For every locomotive about fifteen runs down an incline were made in absolutely calm weather and with initial velocities from 5 to 100 kg. per hour. Curve Fig. 5 gives the specific resistance of the locomotives tested. It shows that the character of the curves obtained by dynamometric measurement differs quite materially from those obtained by letting a car down an incline. Since the greatest difference is observed at high velocities it may be assumed that it is mainly due to frontal resistance which in the first case was determined from the formula $\alpha \; \Omega \; V^2$. It was assumed that the resistance W^1 is the resistance of the locomotive less its frontal resistance, actually, however, since the locomotive is not fully covered by the car in front of it, it experienced in motion a certain pressure of air on a certain part of its frontal surface. Therefore, in order to obtain the total resistance, it is necessary to have added to the resistance W^1, a certain magnitude $\alpha\,(\Omega - \Omega^1)\,V^2$, but if we add $\alpha \; \Omega \; V^2$, the error is made in exaggerating the resistance. If the locomotive is comparatively low, the error would then be less in the case of a high locomotive. From his investigation, the author comes to the conclusion that for locomotives with a leading four wheel bogie, the equation of specific resistance as a carriage may be taken as

$$W_v = 1.4 + 0.02V + 0.005V^2$$

and for a locomotive with a single leading axle

$$V_v = 1.3 + 0.01V + 0.0005V^2$$

It must be remembered, of course, that this formula gives only the resistance of a locomotive as a carriage. The author

passes then to the consideration of the resistance of a locomotive in motion without steam.

From the equation connecting the tangent and indicated traction forces

$$F_k = F_i - W_m$$

it appears that when the throttle is closed, that is when the indicated force of traction becomes equal to zero, the tangent assumes a certain negative value. This is the resistance of the locomotive as an engine with the throttle closed.

Let us call it W'_m. The total resistance of a locomotive is then the sum of its resistance as a carriage and its resistance as an engine with the throttle closed. Let us call it $W_{p.c.}$ Hence

$$W_{p.c.} = W'_m + W_c$$

This resistance was also determined by the "incline" method, and the curves obtained were then submitted in several cases to a special method of double graphical differentiation which the author explains in full.

This method is very convenient for freight locomotives where the resistance at high speeds is not required, and for speeds up to 26 miles per hour it gives good results, but for passenger locomotives, where the resistance at high speeds is of principal interest, it is not applicable. The author has determined the resistance of two passenger locomotives with the throttle closed and obtained formulae of the following kind:

$$W_{p.c.} = 2 + 0.06V + 0.0004V^2 + 0.000013V^3.$$

The cube member is not novel, since Rökl and Desdouits have obtained formulae of resistance with the throttle closed containing such a member and believed that this member characterizes the resistance determined by the mechanism itself. The author passes then to the resistance of eight wheel passenger cars. A number of dynamometric tests were made in 1912 and 1913 by two students of the St. Petersburg Polytechnical Institute who obtained for the summer time, the following formula of resistance:

$$w_n = 1.2 + 0.01V + 0.0003V^2$$

This formula has been, however, obtained under exceptional conditions with special care for the rolling stock, and it is reasonable to assume that the magnitude of resistance as expressed by this formula is really somewhat below the normal. Professor Lomonossff proposed therefore to use for the average conditions of summer traffic a formula:

$$w_n = 1.5 + 0.2V \frac{V + 100}{1000}$$

The author has derived for the conditions of winter traffic, the following formula, based partly on graphical differentiation and partly on the observation of actual velocities on sections of known profile:

$$w_n = 1.5 + 0.5V \frac{V + 10}{1000}$$

These runs were made in November 1913 at temperatures which varied between — 5 and — 15 deg. R. (20.75 and 2.75 deg. fahr.), often in snow and blizzard, and gives the resistance at average conditions. It is, however, only the normal resistance of the cars, that is, not the initial resistance, but a resistance which becomes established after the train has been in motion for a certain time. In winter the resistance at the starting of a train is considerably higher than after the state of operation becomes normal. This is due mainly to the variation in the temperature of the lubricant, and, naturally, when the locomotive takes from the station a train with the lubricant in the journals frozen, the resistance is comparatively very high. The author proceeds to show how these data on locomotive and car resistance may be used for making up schedule of train runs.

Steam Engineering

A Comparison of the Designs of Two Combined Cornwall Tubular Boilers, with Respect to Safety of Operation (*Ein Vergleich der Konstruktionen zweier combinierter Cornwall-Rohrenkessel auf ihre Betriebssicherheit*, P. Koch. *Zeits. fur Dampfkessel und Maschinenbetrieb*, vol. 37, no. 21, p. 255, May 22, 1914, 2 pp., 9 figs. *de*). The author compares two constructions of combined Cornwall Tubular Boilers. In the original construction, the upper and lower drums were arranged in such a manner as to have a water level in conformance with the German Government regulations, both drums being provided with feed water valves and blow-off cocks. The feeding is usually done into the upper drum wherefrom the water passes to the lower drum through an over-flow pipe *a* (Fig. 6A), while the steam spaces in the two drums are interconnected by means of the pipe *b*. This arrangement is in accordance with German Government regulations but does not guarantee perfect safety of operation and requires absolutely reliable attendance. The fireman, in order to prevent all danger of trouble, has constantly to observe the water level of the lower drum and at the same time attend to the feedwater valve on the upper drum. If then strong drawing-off of steam occurs, it may happen that through the over-flow pipe *a*, not so much water reaches the lower drum as the latter requires to compensate for the amount of steam drawn-off, as a result of which some of the fire tubes become uncovered and, by the action of the heat, annealed and deformed. This may result not only from a sudden drawing-off of steam but may be due also to a mistake of the fireman in observing the water level gages on the upper and lower drums. Further the feeding into the upper drum may also endanger regulation of operation. If for example the water level in the upper drum has gone pretty far down, then until a flow of feedwater through the over-flow pipe *a* into the lower drum occurs, a large amount of water has to be delivered into the boiler by means of the feeding apparatus and in the meanwhile the fire-tubes in the upper part remain uncovered and become deformed, which may lead to all sorts of trouble. On account of all this and several other considerations, it was decided to reconstruct the boiler into the type shown in Fig. 6B, which is really an improved Piedboeuf double boiler with one water space and two steam spaces. It has in all one water level in the upper boiler and one feed to take care of.

Explosion of a Rotor of a Laval Turbine (*Die Explosion des Laufrades einer Lavalturbine*, F. v. Plato. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 21, p. 817, May 23, 1914. 5 pp., 13 figs. *dpe*). On August 6, 1912, in the electrical power house of the Libau (Russia) Steel Works Company, there occurred an explosion of the rotor of a 500 h.p. De Laval steam turbine which was so unusual that the following account is of interest. A thorough investigation followed the accident, the results of which emphasize the necessity for preliminary over-speed tests of all similar parts of high-speed machinery. This turbine was coupled by means of transmission gears to two direct-current generators of 2 x 110 volts each. At no-load on the generator it had a

speed of 10,820 r.p.m., equivalent to a peripheral speed of 445 m. (1460 ft.) per second, the ratio of the transmission being 116:30. The turbine which was in operation on the morning of the explosion was provided later in the day with a new rotor shortly before received from Sweden, because the blades of the old rotor had become considerably worn from the water present in the steam (saturated steam at 8 atmospheres was used). Seven turbines of this construction are used in the plant and as the rotors have to be exchanged about once a year, the engineers had had ample experience in this kind of work. After testing by hand to determine the free run of the rotor, the engine as usual was warmed up and in the afternoon slowly started in the presence of the superintendent of the plant who was standing at the side of the casing. One of the engineers stood near the switch board and the other was slowly opening the main steam valve and at the same time observing the manometer have occurred, but never produce as great damage as in this case. A further supposition is that the accident may have been due to a foreign body getting into the casing, which, however, does not appear probable since in the first instance it would cause a considerable amount of noise and would, therefore, show its presence and second by the centrifugal action of the rotor it would have been thrown out onto the rim and cause its fracture in a different manner from what actually took place. All these and other considerations tended to show that the accident was due not to external causes but to weakness in the material of the rotor. The turbine parts were, therefore, carefully investigated at the Mechanical Laboratories at the St. Petersburg Polytechnic Institute, where it was found that the chemical constitution of the metal did not show any undesirable irregularities, while tests of tensile strength, as shown by curves of radial and tangential stresses, also failed to indicate any serious

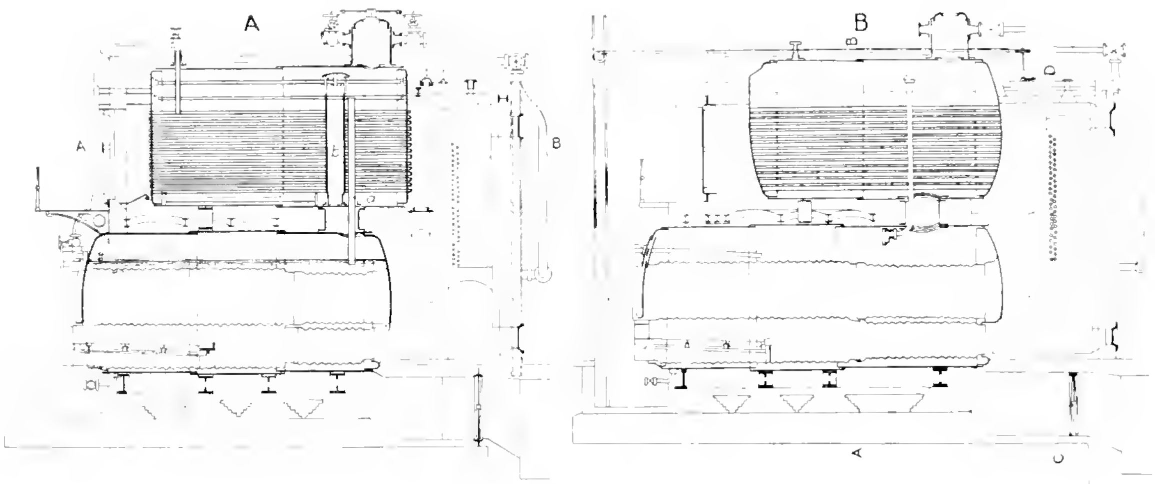

Fig. 6 Two Types of Cornwall Tubular Boiler

located behind the regulating valve and later on stated that the steam pressure rose gradually to 3 or $3\frac{1}{2}$ atmospheres and remained stationary at that point; he then fully opened the throttle and approached the turbine in order to open the necessary number of nozzles as soon as the load was thrown on the turbine. The other engineers were cutting in the excitation current and raising the voltage; when the latter reached about twenty volts the explosion occurred, killing the superintendent and another man present and seriously injuring both engineers.

The article describes in detail the various injuries done to the turbine installation and other machinery and passes to the consideration of the probable cause of the accident. It appears that the governor was not destroyed and while there were indications of corrosion in the governor valve, the amount of steam which might pass through it would not be sufficiently large to cause excess speed. No foreign body could get in between the valve disk and seat since there was wire netting at the inlet. Besides, the turbine ran quite well in the morning and if there were material irregularities in the working of the governor, they could hardly have remained entirely unnoticed before; and finally, if the accident were due to excess speed, the most likely thing to happen would be the flying off of the rim of the rotor weakened by the thread made on it. Such cases of rupture of the rim irregularities. On the other hand a microscopic investigation of the fracture showed that the metal in some places was either partly or roughly crystallized. From the information given by the representative of the concern who built the rotor, it appears that the blades were made from material delivered by an important Swedish metallurgical concern and that the utmost precautions were taken to obtain the best material possible. The pieces when finished are usually tested by the Brinell method and also run for twenty minutes at a speed fifteen per cent above the normal. It appears that in the case of the rotor in question, the Brinell test had been made, but that the test run was omitted. Now the Brinell test indicates only the condition of the surface layers of the metal and gives no information as to possible internal weakness, while very slight errors in the treatment of the metal, especially in its hardening, may lead to the gravest results when the turbine wheel is run at a high speed. It appears, therefore, to be absolutely necessary, when rotors to be run at high speed are supplied, to require properly signed and attested data sheets of a test run of the rotor at a speed 15 to 20 per cent above the normal speed. The great importance of such a test is shown by the tremendous amount of energy stored in a rotor of a De Laval turbine or similar apparatus rotating at high speeds. A disk with its two shaft flanges and bolts as well as the

blades weigh approximately 135 kg. (297 lb.) and has a moment of inertia of approximately 39.5 cmkgs^2 at 10,820 r.p.m. It follows from this that at full speed, the energy stored in the disk is

$$E = \frac{1}{2} I\omega^2 = 25{,}300{,}000 \text{ cmkg} = 253{,}000 \text{ mkg} = 33\,80 \text{ h.p.-sec.}$$

The heaviest piece which broke off from the exploded rotor weighed 27 kg. (59.4 lb.). The peripheral speed of the center of gravity of this piece was approximately 200 m. per second (656 ft.), and when it got free from the disk its energy was approximately

$$E = \frac{1}{2}\,\frac{G}{g}\,v^2 = 55{,}000 \text{ mkg} = 735 \text{ h.p.-sec.}$$

It can be seen from this what a tremendous damage would be done by the sudden liberation of such an amount of energy.

Concerning the Use of Water of Condensation as Boiler Feedwater (*Über Verwendbarkeit von Kondenswasser zum Kesselspeisen*, M. R. Schulz. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 21, p. 257, May 22, 1914. 3 pp., 1 fig. *pe*). A considerable number of com-

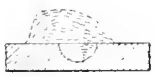

Fig. 7 Boiler Corrosion

plaints have been made lately about corrosion in steam boilers, superheaters, steam piping, etc. Such corrosion is generally local and very small at first, but increases later and finally pierces the material by needle-like passages. It may be recognized by observing on the surface of steam pipes and boiler sheets tiny excrescences of 5 to 10 mm (0.2 to 0.4 in.) in diameter, consisting of iron oxide; when they are removed the typical deepening as shown in Fig. 7 may be observed. Chemists have ascribed the origin of such corrosion to many causes, but a long study of the matter brought the author to the conclusion that they do not depend primarily on the quantity of air or of carbon dioxide in the feedwater, but that both of these do accelerate the corrosion if oil is present in the water. Of late a large number of oil separators for steam have been placed on the market, none of which, however, is as effective as it ought to be. One German manufacturer of oil separators offers to place his apparatus on test for three months and take it back without any compensation whatever, if the separator does not deliver the water of condensation "so free from oil as to be fully safe for use as feedwater in steam boilers" and undertakes further to guarantee that the water will contain not more than 0.01525 g per cbm (0.43 grains per cu. ft.) of water. It appears therefore that even during such a test, when the apparatus is perfectly new and assumedly in perfect order, the oil cannot be entirely eliminated from steam. As regards the further guarantee that the water of condensation would not produce corrosion in boilers, three months is far too short a period to enable the user to form any judgment as no corrosion generally occurs within less than one or two years.

Assuming the above apparatus to work as guaranteed on a battery of ten boilers, each having 100 sq. m (1076 sq. ft.) of heating surface and a 25-fold load applied, there will be evaporated per year 10 × 100 × 25 × 24 × 300 l (47,540,000 gallons), and in this mass of water will be contained, in accordance with the guarantee, approximately 180,000,000 × 0.01525 g = 2745 kg (6040 lb.) of oil; or, taking about 300 lb. per barrel, there will be about 20 barrels of oil per year distributed through the piping, boilers and superheaters. This is, of course, a theoretical calculation, and actually the case would be still worse as no manufacturer of oil separators would guarantee his apparatus to work up to standard for an entire year and longer. The author, however, does not assert that twenty or more barrels of oil per year would be extracted from the steam plant since part of the oil would be vaporized during the steam generation. Enough will settle in the superheaters, pipes, etc., to produce corrosion.

Taking up different types of plants, the author says that using water of condensation as feedwater is general in sugar plants, where very little is heard of corrosion in boilers, due to the fact that as a rule sugar plants are in operation only eight weeks at one time and at the end of the run the boilers and other appliances are thoroughly cleaned. Further,

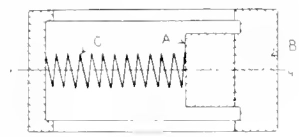

Fig. 8 Polster "Shockmeter"

in the sugar factory, in addition to the water of condensation from the exhaust steam of the steam engines is also used the water of condensation obtained from the sugar tanks, which is perfectly free from oil. The custom in such plants, also, is to add soda to the feedwater and thus produce a saponification of any oil particles that may be present. On the other hand, an entirely different aspect is assumed in many factories of other types.

The author quotes a very striking case of a paper manufactory where the boiler plant for more than fifteen years consisted of two double-flue tubular boilers to which were later added several water tube boilers, all fed by ordinary water direct from a well. Usual methods of mud and boiler scale elimination were used and later on water purification by the calcium-soda process was introduced and no corrosion was observed. The plant was then enlarged and new water tube boilers installed. Since the existing feedwater purification plant was not sufficient to supply all the water required, it was decided to collect the water of condensation coming from the exhaust of the engines, pass it through several oil separators located on the exhaust piping and feed the water thus obtained into a battery of water tube boilers. As a result of this arrangement, corrosion developed several years later in the boilers and superheaters, in the feedwater piping and even in the steam piping, making it necessary to shut down the boiler group. The author then enlarged the water purification plant and had all the water of condensation pass through a process of purification, since which no corrosion has been observed, although the plant has been in operation for over a year. It does not appear that the use of cast iron pipes would improve the situation, and in the case of boilers working at a pressure of eighteen atmospheres or more the government regulations in Germany do not allow the use of cast iron.

Experimental Investigation of Variations of Pressure and Shocks in the Crank Mechanism of Reciprocating Engines (*Experimentelle Untersuchung der Druckwechsel und Stösse im Kurbeltriebe von Kolbenmaschinen*, H. Polster. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 22, p. 867, May 30, 1914. 9 pp., 14 figs. eA). The author mentions the difficulties experienced by the designers of steam engines in attempting to increase the speed of revolution because of "knocking" in the crank mechanism due to the resultant of the steam and mass pressures passing from the positive to the negative side during a single revolution. The pressures on the pins which arise as a result of this knocking are very considerable and may exceed the ordinary journal pressures from five to ten times. While many graphical and analytical investigations of the subject have been made, they have not arrived at uniform conclusions.

The experiments of the author were carried out on a Corliss engine at the Laboratory of Mechanics of the Dresden Technical High School. The engine had 450 mm (17.7 in.) stroke, diameter of piston 180 mm (7.0 in.) and was designed for 160 r.p.m. The piston rod with a diameter of 40 mm (1.57 in.) passes through both cylinder covers and is provided with stuffing boxes and hemp packing. The length of the connecting rod is 1000 mm (39.37 in.), the distance of its center of gravity from the cross-head pin is 673 mm (26.3 in.). The reciprocating mass weighs 45.87 kg. (101.1 lb.), the flywheel has an external diameter 1610 mm (63.3 in.) and its moment of inertia is 56.9 mkgsec² (412.5 ft.-lb. per sec. per sec.). In designing the experimental arrangement of the apparatus it was required to be able to determine the actually occurring maximum shock, the time of the shock, the instant of pressure variation, and in addition it was desired to be able to investigate separately each of the four shocks corresponding to one revolution of the engine. The shock occurring in the crank pin bearing produced a trembling in the connecting rod. If one assumes at both ends of the rod a sufficiently large amount of play, then the connecting rod at the instant of the shock may be considered as a mass having a free motion of flight and the force producing the shock will communicate to this mass a corresponding acceleration which increases in the same proportion as the force of shock, attains its maximum simultaneously with it, and then begins to decrease also simultaneously with it. If now there be a small mass A as in Fig. 8, which is pressed against a certain body B by means of a weightless spring C and if the entire system be accelerated in the direction of the axis $x - y$ then as the acceleration b increases, the pressure between A and B will decrease more and more and at the instant where b equals the tension of the spring, it will become 0. If b be increased still more, then A will get free from B and the two bodies will come back into contact only after the tension of the spring again exceeds the acceleration (no attention is here paid to oscillatory phenomena).

If now such a device as shown in Fig. 8 be placed on a connecting rod in such a manner that its axial direction be parallel to $x - y$, then with the maximum force of shock P kg, a certain definite maximum acceleration b msec^{-2} of the connecting rod in its axial direction will be produced, and by varying the spring tension F, the apparatus can be adjusted in such a manner that the mass m will be either just in contact with A or in such a position that it could not be brought out of contact with it. Whether this happens, can be determined by insulating A from the spring and connecting A and B with the poles of an electric circuit: at the instant when the current is interrupted in the circuit, one can say the $bm = F$ where b is acceleration of B with respect to A in msec^{-2}, m is the mass of A in kg.m^{-1}sec^2, and F is the tension of the spring C in kg. If further M be the total mass of the connecting rod including the mass of B kg.m^{-1}sec^2, then the force applied to the connecting rod will be $P = Mb = \frac{M}{m} F$. This gives a simple way to measure the force of the shock P which otherwise is not easy to determine, from the tension of the spring F which can be easily measured. The author calls this apparatus "shock meter" and describes fully its actual construction which involves quite a complicated system of electrical connections.

As the lack of space does not permit a complete abstract of the article, only the main results of the investigation are reported here. "The Position of Pressure Variation" cannot act as a criterion for the strength and danger of the shock: the shock at the dead center can be just as innocuous as in the middle of the stroke. The speed of revolution of the engine has a certain influence on the pressure rise per second of the over-pressure line, the latter being proportional to the speed of revolution, yet the speed of revolution does not appear to have any further influence on the force of shock. P is a function of only the "pressure rise" per second of the over-pressure line, dimension of play, and lubrication. With increasing play the strength of the shocks increased and then either decreased, or increased less rapidly, in accordance with the kind of pressure variation and of lubrication, which is due to the fact that where there is a larger play, the admission of the oil is more effective. The kind of lubrication has a material influence on the force of shocks, poor lubrication producing hard knocking. A very slight oil pressure is required to reduce to a considerable extent the strength of the blows, and higher oil pressures improve the condition still better but not in proportion to the increased oil consumption. The present article is a valuable extension of the former investigations such as those of Stribeck.

Thermodynamics

Investigation of the Heat Conductivity of Refractory Materials (*Untersuchungen über die Wärmeleitfähigkeit feuerfester Baustoffe*. *Stahl und Eisen*, vol. 34, no. 20, p. 832. 3 pp., 2 figs. e). The present article, which is a communication from the Royal Laboratory for Testing Material at Berlin-Lichterfelde West, in the first place criticises the methods used for the determination of heat conductivity of refractory structural materials. The process often used hitherto and known as the calorimetric method, consists in heating up from an external source a face A of a plate made of the material investigated, and measuring by means of a water calorimeter the heat coming from the opposite face B of the plate after a normal state of operation has been attained. This process has been very much in favor because it makes it possible to obtain a simple formula for the calculation of heat conductivity, but it has many experimental difficulties and is reliable only when the flow of heat in the calorimeter is absolutely uniform: that

is, when each particle of the area of the heated face A communicates its heat to an equally large particle of the area of the opposite face B of the plate. If this condition is not satisfied, as has been for instance the case in some previous experiments, then the values of conductivity obtained may contain errors as high as 100 to 200 per cent. This condition of a uniform flow of heat is extremely difficult to secure when the calorimeter process is used and if by a special complicated method one manages to satisfy this particular requirement, many other sources of error are likely to arise. The calorimeter method has, therefore, been set aside in the present test and another method briefly described has been used instead.

The test plate was built in in a wall made of stones of the same or similar kind, Fig. 9A. The experimental plate (as well as the surrounding bricks) comes in contact by its face K^1 with the plate P, made up of a highly refractory material. The latter is heated by means of a granular resistance mass M (carbon granules) by means of a current flowing through the electrodes R_o and R_u. Actually, and different from what is shown in Fig. A, the thickness of the wall element in the direction of the X axis (the longi-

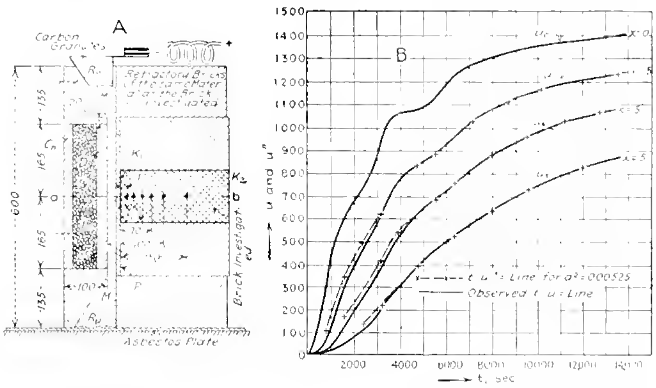

Fig. 9 Arrangement for the Determination of Heat Conductivity of Refractory Materials

tudinal middle line along the experimental brick) was not equal to the length of the brick, but two bricks were placed side by side so as to make the thickness of the wall element equal to two lengths of brick. In the longitudinal axis of the experimental brick are located the soldered-in points of the thermo-elements, as shown in the drawing. The main thermo-elements were thus located at $X = 0$ and $X = 1.5$ cm measured from K_1. All the other connections were used only for the additional control of the tests. After the heating current has been placed in circuit the temperatures u_o at $X = 0$ and $u_{1.5}$ at $X = 1.5$ cm is read at regular intervals of time by means of the thermo-elements and in this way two curves are obtained with T in seconds as abscissae and the temperatures u_o or $u_{1.5}$ as ordinates. (Fig. B.) These curves may be called $t - u$ curves; the temperature u is not the actual temperature, but the excess over the temperature of the external air at the point of measurement. If the heat conductivity of a material is called k, its specific heat c and its weight per unit of volume s, then $a^2 = \frac{k}{c.s}$ is the so called temperature coefficient of conductivity which, just as k, is a function of the temperature u. If one assumes that a^2 is constant, that is, independent of temperature, from the shape of the u_o curve and under an assumption of various values for a^2, one may calculate the position of the $t - u$ curves for various distances X, these lines being called for the sake of distinction $t - u''$ curves. By comparing the calculated $t - u''$ curves with the $t - u$ curves observed from actual experiments, one may draw some conclusions as to a^2 which first shows the specific properties of the material tested and in the second place gives information as to the law of its variation with temperature.

ENGINEERING SOCIETIES

AMERICAN INSTITUTE OF MINING ENGINEERS

Bulletin, vol. 89, May 1914. New York.

Turbo-Blowers for Blast Furnace Blowing, Richard H. Rice (abstracted)

Data pertaining to Gas Cleaning at the Duquesne Blast Furnaces, A. N. Diehl

Is it Feasible to Make Common Carriers of Natural Gas Transmission Lines, Samuel S. Wyer

The Progress of the Metallurgy of Iron and Steel, Sir Robert Hadfield

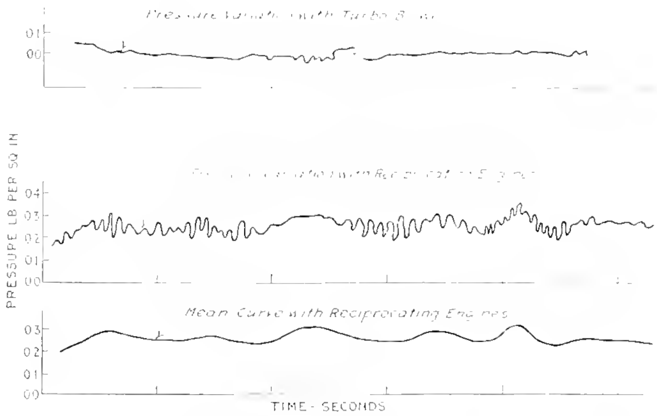

Fig. 10 Pressure Curves of Turbo-Blowers and Blowers Driven by Reciprocating Engines

Turbo-Blowers for Blast Furnace Blowing, Richard H. Rice (22 pp., 9 figs. *dgp*). The paper presents a review of the experience gained and the present state of progress in the design of turbo-blowers for blast furnace blowing. On account of lack of space only certain parts are here abstracted. It has been frequently contended that the blast from the reciprocating engine is just as steady as that from the turbo-blower and that pulsations due to intermittent discharge from air tubs were smoothed by the frictional resistance of blast main and stoves. In order to settle this question a special measuring instrument devoid of inertia was designed, making it possible to obtain a record of the pressure variations in the blast. The record shown in Fig. 10 was made on a furnace working on Southern iron and at the time it was blown with reciprocating engines there were four engines in use, two of which had steam cylinders 84 in. in diameter and air cylinders 84 x 60 in. stroke, while two had steam cylinders 44 in. in diameter and air cylinders 84 x 60 in. stroke and were operated at an average speed of 40 revolutions per minute, giving a total displacement of about 60,000 cu. ft. of air per minute. They were of the vertical long crosshead type equipped with Corliss air inlet valves and modified Reynolds type discharge valves. The curve obtained when operating in this manner apparently consists

of a primary wave and a secondary wave, the first being due to the discharge of the reciprocating cylinders while the secondary waves may be caused by the fluttering of the discharge valves. In contrast with this is shown a comparatively flat curve of pressure variations observed with the turbo-blowers. The article describes also the design of a constant volume governor for centrifugal compressors and gives some data on the performance of reciprocating steam engines, gas blowing engines and turbo-blowers, but comes to the conclusion that the gas consumption of the reciprocating steam blowing engine is so high as compared with that of a turbo-blower that it is not possible with any form of blowing engine to come within reasonable range of the turbo-blower in this respect. The steam practice of blast furnace and steel works is hopelessly behind the times and needs entire revision, but with the introduction of the turbine-driven plant in which modern economical steam practice is applied there is a lower cost of operation, less stoppage and loss of product, and a larger product for the same furnace and one of better quality than by any other prime mover now in use for the purpose.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Journal, vol. 26, no. 2, May 1914. Washington, D. C.

Operation and Trials of the U. S. Fleet Collier "Jupiter," S. M. Robinson (12 pp., 5 figs. *eg*). The article describes operation and trials of the U. S. Fleet Collier Jupiter, equipped with an electric system of transmission between the turbine plant and propellers. The manoeuvering qualities of the electric drive have proved to be highly satisfactory; when the resistances are in, the operation is practically instantaneous and this makes it possible to use the engines to help the rudder. There are several conditions of operation which are peculiar to the electric drive. One is that if operated at all, both motors must go at the same speed; that is to say, it is not possible to go full speed ahead on one of the motors and slow astern on the other. Another peculiarity is that when the ship turns the inboard screw does not slow down but keeps the same speed as the outboard. This results in a slightly larger turning circle at high speed, but apparently the increased pressure on the rudder under these conditions nearly makes up for the effect of the higher speed of the inboard screw. One of the advantages noted in the behavior of the electric drive at sea was the total absence of racing. The governor so effectually prevents this that even with bad pitching there was no change in speed of the motors when coming in or out of the water. Another advantage of the governor is the great accuracy with which any desired number of revolutions can be maintained. The control wheel once set will maintain the same speed within a small fraction of a revolution for an indefinite period of time, regardless of changes in vacuum or steam pressure.

The article gives data of tests in the form of tables and curves. The ship had a water consumption per s.h.p. hour in the 48-hour test of 11.68 lb. (turbine) and in the 24-hour test 12.316 lb. fuel consumption in pounds of coal per hour per s.h.p. 1.662 and 2.5056 respectively, developing 15.9 and 4.48 (?) s.h.p. per square foot of grate surface and 2.82 and 4.43 knots per ton of coal.

The Effect of Mixing Oils in Forced-Lubrication Systems, G. S. Bryan (10 pp., 2 figs. *e*). In the Service of the United States Navy trouble has been experienced in the forced-lubrication systems of main engines and turbines and it has been frequently suggested that this trouble might possibly be due to the mixing of two or more oils in the same system. In order to decide whether or not mixing oils had any harmful effect, a series of tests was undertaken at the Engineering Experiment Station at Annapolis with eight oils, five of which were paraffine base and three asphalt base oil. The test was divided into three general parts: (*a*) tests in oil testing machine, (*b*) chemical examination for condition of refinement and determination of the physical constitution before and after use in above machine, and (*c*) test of oils mixed with steam and water. A special oil testing machine has been constructed to reproduce forced-lubrication conditions. These tests have demonstrated that no harmful effects result from mixing any or all of the oils tested. It is believed that the eight oils tested are representative enough to cover the field of oils for forced-lubrication and that the conclusions drawn from these tests will apply to all straight mineral oils used in forced-lubrication systems. The article gives also some data on mixtures of oil with steam and water and "separated matter" obtained. This "separated matter" took the form of a thick jelly-like emulsion. The same character of emulsion was formed by bubbling steam through the oil for a few minutes; when the mixture was stirred under 50 lb. steam pressure, the emulsion disappeared and a different kind of "separated matter" made its appearance.

Empirical Formula for the Weight of Steam Passing through a Venturi Tube, John B. Grumbein (2 pp., 1 fig. *et*). The author derives a new formula for the weight of steam passing through a venturi tube, different from the Rankine formula. Fig. 11 gives the results of a series of actual experiments on the venturi meter as compared with the calculated results from the Rankine formula for the flow of steam through orifices. The dotted line corresponds to zero error, the full line to the results obtained by the Rankine formula; these results were 4.9 per cent greater than indicated by the Rankine formula and the experiment indicates that the coefficient 42 employed by Rankine for orifices should be replaced by 40 for the venturi tube. For the venturi meter the author modifies the Rankine formula as follows:

$$W = a_t p_t \, 0.03062 \left(\frac{P_e - p_t}{p_t} \right)^{\frac{1}{2}}$$

where W is pounds per second, a_t area of the throat in square inches, p_t pressure in the throat, pounds per square inch absolute, P_e pressure entering meter, pound per square

inch absolute. The formula has been developed in the laboratories of Sibley College.

ASSOCIATION OF ENGINEERING SOCIETIES

Journal, vol. 52, no. 5, May 1911, St. Louis, Mo.

Timber Conservation and Preservation in the United States, E. L. Powell

New Turbine Pumps of the St. Louis Water Works, L. A. Day (abstracted)

Engineering and Accounting (Discussion).

New Turbine Pumps of the St. Louis Water Works, L. A. Day (13 pp., 4 figs. *de*). The article describes the steam turbines and centrifugal pumps of the St. Louis Water Works. Some time ago when the safe working capacity at the Chain of Rocks Station in St. Louis had been reached, it was decided to replace two 20,000,000 gallon Worthington pumps with centrifugal pumps of greater capacity, namely, two 40,000,000 gallon pumps. Two such pumps of the reciprocating type would have cost approximately $230,000, the duty in feet pounds of work per thousand pounds of steam of the reciprocating type being approximately 150,000,000. Two 40,000,000 gallon turbine centrifugal pumps cost $55,000 with an average duty of 94,000,000, while the maintenance cost in the first case would be about $780 per pump per year and in the second $550. In capitalizing the investment the following formula was derived:

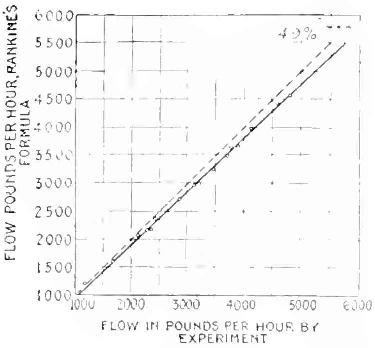

Fig. 11 Curve of Flow of Steam through a Venturi Nozzle

$$\frac{A_x W_x H_x P}{D} + F(i+d) + L + M = C$$

where A is the total number of gallons pumped per year, W weight of a gallon of water, H average total head in feet pumped against, P cost of steam per 1000 lb., D average duty in foot pounds per 1000 lb. of steam, F total investment, i rate of interest on investment, d rate of depreciation, L yearly cost of operating labor, M yearly cost of miscellaneous expenses of operation, C total cost per year. Solving for C with both types of pumps, a difference of $13,000 was obtained in favor of the turbine driven pump, which means that in a little more than four years the centrifugal pumps will have paid for themselves. Needle ice suspended in the river water during the winter and sand throughout the year are additional important reasons for installing centrifugal pumps. On account of these conditions, a contract was given for two De Laval 525 h.p. steam turbine driven centrifugal pumping units each to have a capacity of 42,000,000 gallons in 24 hours working, under a total head including friction in the suction and discharge pipes of 46 ft.; a capacity of 40,000,000 gallons under a total head of 56 ft. and a capacity of 30,000,000 gallons under a total head of 63 ft., the 46 and 63 ft. heads being the minimum and maximum heads at that station, due to the different stages of the river throughout the year.

Each pumping unit consists of two single-stage double-suction 24 in. volute pumps without diffusion vanes and with impellers of the closed type. The double suction impeller practically eliminates end thrust, but a marine thrust bearing is provided at the end of the pump shaft to take care of any thrust, which might occur if for instance something should become lodged in one side of the impeller and prevent the proper filling of the pump on that side. Although manganese bronze proved satisfactory, Government bronze will be used when the impellers require renewal because it can be much better cast than manganese bronze. The pump case is horizontally divided through the center of the main shaft, and when the pump case cover is removed an examination of all working parts can be made without disturbing any of the pipe connections. The only moving parts are the shaft and impeller and the only wearing parts are the wearing rings, bearings and shaft protecting sleeves

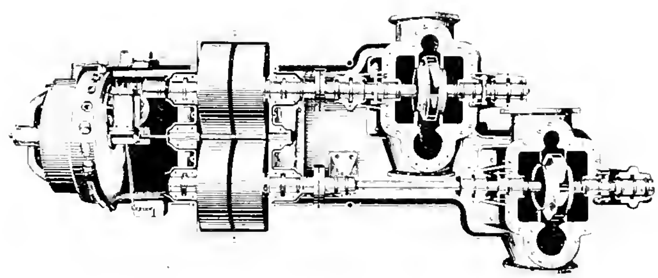

Fig. 12 Bearings of the Turbine Pumps of the St. Louis Water Works

(Fig. 12). The stuffing boxes contain soft packing with a hollow skeleton ring in the middle of the packing to which clear water under pressure is admitted forming an air tight seal and preventing loss of suction. The shaft in the stuffing box is protected by a bronze sleeve which forms a bearing for the packing and can be easily removed when worn or scored. The shaft proper being thus subject to no wear.

The final tests have given the following results: Head, 53.06 ft.; delivery, 42,900,000; duty, 96,800,000; head, 55.46 ft.; delivery, 30,040,000; duty, 93,800,000. The impellers were changed after installation and the following results obtained: Head, 58.86 ft.; delivery, 38,480,000; duty, 104,100,000; head, 62.15 ft.; delivery, 36,458,333; duty, 101,600,000.

Answering questions in the discussion which followed, the author stated that the best speed at which the pumps should run is to a great extent a matter of calculation and it is likely that as far as the exact speed is concerned each pump would have its own particular characteristic. For instance, the design of the wearing ring would affect the capacity of the pump and the builders themselves have constants which they use and of which they did not inform the purchasers. The speed is not changed with the change of head. The mechanical efficiency of the aggregate will run around ninety-five per cent over all, vacuum being 27 to 28 in.; at full load,

the steam consumption was 15.1 lb.; at one half load 16.3 and at three-quarters load 16.1 lb.

AUSTRALASIAN INSTITUTE OF MINING ENGINEERS

Proceedings, New Series, no. [illegible], Melbourne.

THE REQUIREMENTS OF ECONOMICAL WINDING, J. Armstrong Turnbull (43 pp., 37 figs. p). The paper describes the main points for special consideration regarding winding engines used in connection with vertical and inclined shafts. The article is of a practical nature and on account of lack of space only certain few points will be referred to here. Head frames are usually constructed of wood, owing to its supposed cheapness. Wooden head frames, however, require quite a number of extra members; not from a load resisting point of view, but from the standpoint of mechanical construction. As an iron or steel frame can be designed so as practically to reduce redundant members to a very small degree, often the iron or steel frame is the cheaper of the two, besides having a life at least four or six times longer than that of wood. The pit-head pulleys should be at least three quarters the diameter of the winding drum and, preferably, the full diameter of the latter. The losses due to these pulleys are directly proportional to the weight of wheel, its load and diameter of journals multiplied by the revolutions per wind. Hence, these wheels should be large in diameter, and have as small journals as is consistent with strength. It is, however, necessary that the total weight of head pulleys should be kept low, for other reasons than frame strains, viz., in the case of a heavy pulley where the inertia may exceed the rope load, the wheel may continue to revolve after the wind is finished and injure the rope. All winding shafts should be equipped with cages having the following automatic safety appliance: a spring buffer draw-bar, in addition to the usual suspension chains and adjusting screws; safety catches to grip either wooden, iron or pliable slides and automatic stops which cannot be tampered with unless the cage is resting on the shaft catches; overwinding automatic disengaging hook; and a special set of additional catches with adjusting screws placed in the head frame so that the cage or skip when in the overwound position will just press through them and be not more than 6 in. above them when unhooked. The saving of property in the event of an accident more than compensates for their initial and maintenance costs. The author discusses in detail the conditions of balancing on the engines and comes to the conclusion that it is very necessary to keep down the size of winding rope as this causes the largest amount of unbalancing effect on winding engines. He discusses further the principal methods of balancing winding engines, among others the continuous rope systems known as the Koepe and Whiting. It appears, however, that the introduction of any of these systems of winding acts not so much as a means of balancing as a means of reduction of rope abrasion, although these systems especially lend themselves to the suitable application of the tail rope as a balance. The author describes in detail and illustrates the construction of winding engine cylinders and the question of their clearances. The acceleration required in a winding engine is perhaps one of the most severe requirements that steam engines are ever called upon to meet and to ensure the best operating conditions the automatic governor-control cut-off must act within the first two revolutions of the winding drums, and it is most important that there be no hesitation on the governor's part in getting up to speed. The author discusses also in considerable detail the brakes used on winding engine drums as well as the automatic stop motions, and passes on to a brief discussion of electric winding engines.

EIGHTH ANNUAL CONFERENCE OF WEIGHTS AND MEASURES

Washington, D. C., May 1913 (abstracted from manuscript).

SCALE CONSTRUCTION, A. BOUSFIELD. It is of a great advantage to weigh freight cars in motion, but to do this well, the lever system of the scale must be sufficiently heavy to resist, without undue deflection, the effects of the moving loads and the platform must have perfect freedom of motion in both planes and if moved slightly from its normal position, must return promptly to position and balance. The suspension or pendulum system of scale construction appears to be the most accurate that has yet been evolved and for weighing loads is superior to old rigid bearing types. There are three distinct types of levers used in scale construction. The straight line solid lever type is particularly well adapted to track scale work, where great rigidity is an all important feature. The straight line trussed lever type is well adopted to wagon scales where platforms are large and the capacity light. Pipe or torsion levers are adopted to scales which are to be applied to hopper and charging cars. The principal objection to this type of lever is that for heavy capacities the cylindrical portion has to be made very large and heavy, in order to resist the combined bending and torsional strains induced by the loading. If, however, long fulcrums are used and the bending and torsional stresses kept low, rigid and accurate scales can be designed and built with pipe levers. In designing scale levers, it is necessary not only to consider the safe working stresses to which the various materials used may be subjected, but the deflection of the levers under load must also be considered, as one of the sources of error in a scale is the elasticity of the material. Bending and twisting of the lever system tends to change the multiplication and produce alterations in the state of equilibrium. If the size of important members is so reduced as to produce excessive stresses, accuracy will be materially sacrificed when the scale is loaded to full capacity.

Pivots and knife edges may be considered as infinitely small rollers, rolling upon their foundation or bearings. Either a perfectly flat bearing or one whose surface is formed by a large radius is better than a sharp V bearing since with the latter an element of friction is introduced. In some types of special construction the V bearing is a necessary evil. The correct angle for knife edges and pivots has never been very definitely determined. The angle of 90 deg. gives good results for heavy loads, but for scales of light capacities a sharper angle is desirable and for scales up to 150 lb. capacity may be 45 deg. The end to be aimed at in establishing the correct angle for pivot and knife edges is to determine the angle which will enable the pivot to support the greatest load with a minimum wear under all conditions. There is a general agreement among scale designers that the greater the load, the greater should be the angle of pivot or knife edge. The bearing pressure per lineal inch of knife edge has an important bearing on

the enduring accuracy of the mechanism in scales subjected to heavy loads in motion. A load of 5000 lb. per lineal inch will be found sufficiently high. The material almost universally used for knife edges and bearings of large scales is steel. The contact surfaces should be extremely hard while the remainder of the structure should retain toughness and ductility.

In designing levers for scales which are subjected to severe shocks due to the effect of moving loads, an allowance of 100 per cent for impact should be made. It is poor practice to stress the material up to the elastic limit, for when this is done, undue deflection is introduced and this will probably cause inaccuracies when the scale is loaded to full capacity. Before construction work is started, calculations should always be made to determine deflection. In levers for heavy scales it is desirable to have the pivots and knife edges reinforced by projections cast integral with the levers. Where the arc of movement is large, it is desirable to have the pivots placed on the neutral axis of the section to insure an equal distribution of mass about the pivot line. There is nothing of greater importance in the manufacture of scales than the sealing of the levers and beam. Levers of large capacity should be sealed with test weights as heavy as it is practical to handle. It is almost impossible to detect slight discrepancies with light test weights. The notching and marking of the beam is an operation of precision and it is almost impossible to manufacture a machine of sufficient accuracy to do the work without its finally being sealed by a skilled workman.

In testing grain hopper scales of large capacity, such as 2000 bushels, the following method of procedure will give good results: Suspend a temporary framework from the scale platform framing and place 2000 lb. of test weights on each corner successively, testing the beam after each corner has been loaded. When the loading of the last corner has been completed, a load of 8000 lb. of test weights will be placed upon the scale. Then run grain into the hopper until the full capacity has been reached. Rebalance the scale and remove the weights from each corner separately, checking each corner respectively as it is unloaded. Grain hopper scales work under almost ideal conditions since the loads are gradually and steadily applied and removed.

What is probably the largest and heaviest track scale in the world has been recently constructed for the Norfolk and Western Railroad. This scale is 68 ft. long and made in four sections. 5 ft. 6 in. protective overlap is used at each end giving a 57-ft. weighing rail. The main lever stands are placed directly upon concrete foundation and all pocketing of piers is eliminated. The scale is built on 0.75 per cent grade obtained by the use of grade blocks placed under the main girders, the latter being designed as a box chord, and made in three sections so as to eliminate the objectionable upward reaction of the extreme ends. The main levers are cast steel with the load and fulcrum pivots 15 in. long and with the tip pivots 7 in. long. The multiplication of the lever system is 24 at the tip of the extension lever, 200 at the tip of the fifth lever and a multiple of 400 at the butt of the weighing beam. The main bearings are of the suspension type, arranged so as to give perfect freedom and also retain perfect alignment with the pivot edges at all times and without movement of the lever system. The main suspension links, the cross-bars and rockers are of cast steel. The maximum stress allowed in the members under an assumed load of 100 tons is 6000 lb. per square inch in cast steel, 2000 lb. in cast iron, 8000 lb. in structural steel, all three in tension. These scales have been designed for weighing in motion some especially heavy coal cars which have recently been designed by the Norfolk and Western Railroad.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

Journal, vol. 6, no. 2, 1914. Columbus, O.

The Taylor Stoker Operating under Average Conditions, Horace Judd (abstracted)
Steam Boilers, Their Construction and Inspection, H. A. Baumhart
Centrifugal Boiler Feed Pumps, Edward S. Adams
Uniflow Steam Engine, James H. Debes

The Taylor Stoker Operating under Average Conditions, Horace Judd (paper no. 192, 23 pp., 6 figs. eA). Such stoker trials as have been reported have for the most part been conducted under favorable conditions with boilers and furnaces often of unusually large size and operated under expert guidance. There has frequently been a query among power plant men, however, as to whether the stoker in units of moderate size and tended by the average fireman would give the same favorable showing. The author (assistant professor of experimental engineering in the Ohio State University) during the past year has had an opportunity to make a series of evaporative tests with ordinary attendance at the boilers, and the boiler equipment working under usual commercial conditions. Six of the boiler trials were conducted in March 1913 on a 250 h.p. Babcock & Wilcox boiler of the cross drum type, forming the boiler equipment at the Troy Laundering Company, Columbus, Ohio, and three trials were made on a 300 h.p. Flanner boiler of the same type at the Power Plant of the Ohio State University, Columbus, Ohio. The boilers at both places were equipped with three retort Taylor stokers. The coals in the trials at the laundry were soft coal from West Virginia, Hocking and Pittsburg. The flue gases were passed to a Greene fuel economizer of the usual manifold construction but of unusually large size to give a large storage capacity of hot water for laundry use. At the laundry 10 hours is the average length of time during which the steam supply is needed and this was taken as the duration of the trial with readings every fifteen minutes and flue gas analyzed every half hour from a continual drawn sample. The results obtained from the trials of the laundry indicate on the whole a satisfactory performance for a boiler equipment of the smaller size unit when operated under overload conditions with the ordinary care of the average fireman. The stoker is easily and rapidly cleaned if the clinkers are not allowed to collect to such an extent as to prevent the proper and ultimate mixtures of air with the fuel. The ease with which the dumping process is managed depends largely upon the clinkering properties of the coal. For dump periods ranging from two to three hours, the percentage of unburned coal passing into the ash-pit averaged 4.36 per cent in seven trials. With one hour dump periods, the average unburned coal loss was 9 per cent, showing that the unburned coal loss varied about inversely as the length of the dump interval. It appears that sulphur gave the most trouble from clinkering and in addition sometimes produced very unpleasant fumes. The coal feed is uniform and positive and under

control through the speed regulator on the fan engine. For the different kinds of coal used, the average rates of combustion are given in Table 3. Close air regulation is also possible. During the tests at the laundry, owing to the extremely variable load, the draft over the fire showed a wide instantaneous variation ranging from a pressure slightly above zero to as much as 0.05 suction, though the average results were fairly uniform. The smoke observations were taken with a Ringelmann smoke chart at the heaviest load period during each day's run and showed about the same degree of density for each day. The overload capacity and efficiency is shown in Table 4 which contains the average results for the combined boiler, furnace and grate efficiencies at overload capacities for the nine trials. The trials showing the lowest efficiencies were those when Pittsburg No. 8 coal was used. This coal gave the most trouble in clinkering and also seemed to be a higher coking coal than the other two kinds used. The extreme fluctuation in the load of the laundry made it difficult to regulate the thickness of the fire and this fact emphasizes the need of maintaining a boiler test for at least ten hours unless the load should remain fairly uniform. These results do not give the high efficiencies obtained in trials where the load is carefully regulated, flue gas conditions watched and the combustion adjusted so as to reduce the furnace losses to a minimum. But even in these tests made as far as possible under average operating conditions, it appears that a fairly high overall efficiency for the Taylor type of stoker is within reach of the average fireman. The factors chiefly controlling the efficiency of a Taylor stoker at overload capacity appear to be: the size of unit, per cent of overload, character of coal, the use of indicating boiler room appliances, and the intelligence of the fireman, the latter being without doubt the factor of most importance.

TABLE 3 AVERAGE RATES OF COMBUSTION FOR DIFFERENT COALS

Trial No.	Kind of Coal	Lb. per retort per rev.	Rev. of stoker per hr.	Coal per hr. per sq. ft. grate	Coal per hr. per boiler h.p.
1	W. Va. Splint	15.0	36.0	39.3	3.78
2	W. Va. Splint	16.1	32.8	38.1	3.72
3	Hocking	14.8	36.3	39.0	4.31
4	Hocking	15.8	41.0	47.5	4.73
5	Pitts. No. 8	15.9	38.4	44.5	4.19
6	Pitts. No. 8	15.9	36.8	42.8	4.21
7	W. Va., Fairmont Region	15.8	38.5	35.6	4.06
8	W. Va., Fairmont Region	16.6	41.7	46.0	3.96
9	W. Va., Thacker Coal F'ds., wash.	17.3	51.8	56.2	4.36

TABLE 4 OVERLOAD CAPACITY AND EFFICIENCY

Trial No.	Per Cent Rating	Equiv. Evap. per lb. actual coal	Equiv. Evap. per lb. comb. burned	Efficiency boiler, grate and furnace	Coal per hr. per boiler h.p.	B.t.u. actual coal	Radiation, etc.
7	126	8.49	10.75	67.6	4.06	12184	12.78
3	149	8.03	10.97	69.9	4.31	11164	5.65
4	165	7.31	10.17	67.1	4.73	10570	8.39
6	167	8.24	10.09	63.5	4.21	12582	12.93
2	171	9.26	11.86	72.5	3.72	12375	1.25
1	172	9.15	11.02	69.9	3.78	12697	7.19
5	176	8.25	10.17	66.3	4.19	12067	9.75
8	167	8.71		65.8	3.96	12830	12.48
9	186	7.96	10.11	59.0	4.34	13120	15.82
					av. 4.15		

PERSONAL NOTES

Nicholas S. Hill, Jr., consulting engineer of New York, sails for Europe on July 7 for the purpose of making an investigation and study of the German and English water and sewage plants. He will return to this country about September 1.

Jay G. Coutant, formerly engineer of plant of the Lima Locomotive Corporation, Lima, Ohio, who has specialized in the burning of powder fuel and water gas, has taken up the same work for the Railway Materials Company, Chicago, Ill.

A. A. Potter, for several years professor of steam and gas engineering at the Kansas State Agricultural College, was made dean of the engineering division and director of the engineering experiment station of the same institution. Mr. Potter will still retain the professorship in steam and gas engineering.

Daniel Webster Mead, professor of engineering in the University of Wisconsin, Madison, Wis., has been appointed a member of a Board of Engineers for the prevention of floods in Eastern China through a $20,000,000 reclamation project.

Alexander G. Christie, associate professor of steam engineering, University of Wisconsin, has been appointed associate professor of mechanical engineering in the College of Engineering which Johns Hopkins University is now organizing and building.

Harry L. Brunger has become affiliated with the Aultman-Taylor Machinery Company, Mansfield, Ohio. He was until recently in the employ of M. Rumely Company, La Porte, Ind., in the capacity of chief draftsman.

Theodore A. Leisen has been appointed general superintendent of the Board of Water Commissioners of Detroit, Mich. He was formerly associated with the Louisville Water Company, Louisville, Ky., as chief engineer and superintendent.

Arthur M. Crane, late sales manager of the Permutit Company, New York, has returned to the New York Continental Jewell Filtration Company, New York, and will have charge of the pressure filter business.

Arthur J. Beerbaum has accepted a position with the Western Electric Company, Chicago, Ill., in the plant engineering department. He was formerly associated with The Arnold Company of the same city, in the capacity of draftsman.

William Floyd Lee, chief engineer of C. W. Hunt Company, Inc., West New Brighton, S. I., N. Y., at a recent meeting of the Board of Directors, was elected vice-president and chief engineer of the company.

Frederic E. Pierce has terminated his connection with The New Jersey Zinc Company, New York, in whose employ he has served for over 15 years in various capacities, for the latter part as chief engineer, and has opened an office to engage in consulting work in civil and metallurgical engineering.

R. H. Danforth, who has been for the past six years connected with the U. S. Naval Engineering Experiment Station and the Post Graduate Department of Engineering of the U. S. Naval Academy, Annapolis, Md., has been appointed professor of mechanics and hydraulics at Case School of Applied Science, Cleveland, Ohio.

STUDENT BRANCHES

KANSAS STATE AGRICULTURAL COLLEGE

On May 18, Leland C. Angevine, chairman of the Student Branch at the University of Kansas, gave a talk on the work of his Student Branch, telling of its success and general plan.

Chief Engineer Polling gave an illustrated lecture on the Metropolitan Power Company of Kansas City, Mo., explaining in detail the operation of the units of power production and the method of handling the condensors.

R. J. Taylor, senior student, gave a discussion of the Kansas City, Mo., Water Supply, explaining the treatment of the water to remove the impurities and render it fit for use.

LEHIGH UNIVERSITY

On May 19, Lehigh University Student Branch elected the following officers: A. V. Bodine, president; E. P. Humphrey, bursar; H. A. Brown, secretary; P. G. De Huff, librarian.

OHIO STATE UNIVERSITY

On May 28, the Ohio State Student Branch held a farewell banquet in honor of the Senior Students in mechanical engineering. The following officers for the ensuing term were elected: R. D. Rogers, chairman; C. L. Brown, vice-chairman; W. W. Watson, secretary; K. W. Stinson, treasurer: E. M. Mathews, sergeant-at-arms.

PENNSYLVANIA STATE COLLEGE

At a meeting of the Student Branch of Pennsylvania State College, the following officers were elected for the first semester of the next college year: C. F. Kennedy, president; V. D. Longo, vice-president; W. A. Blume, treasurer; D. E. Hewitt, secretary. Reports were made by the chairmen of the various standing committees and by the treasurer.

Mr. Meyers, a graduate of Stevens Institute of Technology, spoke briefly on the manufacture of iron and steel.

UNIVERSITY OF CINCINNATI

The annual election of officers of the Student Branch of the University of Cincinnati was held in conjunction with a smoker on May 16. The following officers were chosen: J. Hollman, president; R. Rickwood, vice-president; A. J. Laughammer, secretary-treasurer.

Prof. John T. Faig, the honorary chairman of the Branch, gave an address on Utilization of Coal. He discussed the present methods of using the "black diamond," the subsequent nuisances occasioned thereby and remedial measures. Special emphasis was placed upon the efficient utilization of coal by the by-product coke ovens and upon the possibilities in this field.

UNIVERSITY OF MICHIGAN

At a meeting of the University of Michigan Branch on April 23, the following officers were elected to serve until January 1915: R. H. Mills, chairman; C. H. McClellan, recording secretary and treasurer; J. R. Allen, honorary chairman.

On May 18, J. R. McColl gave his paper on Tests of Vacuum Cleaners. Mr. McColl completed his talk with a demonstration in which he showed his method of measuring air pressures in vacuum systems and the effect of different sized orifices upon these pressures.

UNIVERSITY OF MINNESOTA

The regular meeting of the Minnesota Student Branch was held May 7. John Peoples presented a paper on the Efficiency of Rope Driving, which was followed by a discussion.

A. L. Baenger who represented the Student Branch at a meeting of the Executive Committee of the St. Paul-Minneapolis Section gave a report of the meeting.

On May 27, a special meeting was held at which Max Toltz of the St. Paul-Minneapolis Section addressed the Student Branch in regard to being present at the Spring Meeting of the Society.

UNIVERSITY OF MISSOURI

The Student Branch of the University of Missouri held a joint meeting with the Electrical Engineering Society on May 4. Professor Hubbard gave an illustrated talk on the Engineering Societies Building in New York.

At a meeting on May 18, F. H. Heileman gave a talk on

heat treated steel, the benefits derived from heat treatments and the difference between the strength of heat treated and alloy steels.

UNIVERSITY OF NEBRASKA

Engineers week was held during May 4-9 at the University of Nebraska. The events included an address by H. W. Stannard, on Scientific Shop Management, and a smoker at which 250 students were present. All classes were suspended on Friday and in the evening all the engineering laboratories were open to visitors, about 2000 of whom inspected the equipment. The mechanical engineering laboratories were the center of attraction, and about 500 souvenirs cast from aluminum in the foundry were given away to the guests. A photograph of these souvenirs is given herewith.

The concluding event of the week was a banquet on Saturday evening, at which 350 were present, Bion J. Arnold acting as toastmaster. The speakers included Gov. T. H. Morehead; E. J. Robinson, engineer of valuations of C. B. & Q. R. R.; W. J. Provaznik, city engineer's office, Omaha; George H. Tinker, bridge engineer for N. Y. C. & St. L. R. R.; B. C. Yates, asst. chief engineer, Homestake Mining Co.; H. E. Reagan, president U. S. Equipment Co., Chicago; and Lieut. Col. Herbert Deakyne, Engineering Corps U. S. A.

On May 19, at a meeting of the Student Branch, the following officers were elected: B. F. Merriam, chairman; L. L. Westling, secretary; D. W. Watkins, treasurer; and H. S. McNabb, publicity man.

A special meeting of the Branch was held May 21, to which the Engineers' Club of Lincoln was invited. B. F. Hart of the National Tube Co. of Chicago gave a lecture on the manufacture of steel tubing illustrated by slides and three reels of motion pictures. The pictures showed the processes of manufacture from the mine where the ore was obtained to where the pipe was being shipped. After the lecture, the meeting was open for discussion.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing positions for members. The Secretary gives this his personal attention and is pleased to receive requests both for positions and for men. The published list of "men available" is made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

POSITIONS AVAILABLE

523 Salesman for offset printing presses.

524 Salesman who has been a success wanted by Pennsylvania concern; prefer a man who has had experience in sale of boilers or stokers or large power plant apparatus.

526 General Manager who will be willing to invest ten to twenty thousand dollars and thoroughly in sympathy with modern manufacturing methods, wanted for concern manufacturing machinery of every profitable nature. Name confidential. Apply by letter.

601 Company in Middle West have opening in experimental mechanical department for a responsible man experienced in machine design, capable of supervising the work of draftsmen, following it through the shop and developing into practical operation.

604 A large company desires the services of a mechanical engineer who is thoroughly familiar with and capable of passing on locomotive and car design; preferably one who has been connected with a railroad and has had practical as well as theoretical experience. Salary $300 to $350. Apply through Society.

605 Shop superintendent who is familiar with modern shop practice and up-to-date manufacturing methods, for factory located in the east and manufacturing light mechanical and electrical devices. State experience, references and salary expected.

609 Chief engineer to take charge of power plant consisting of a steam and electrical plant. Location, Pennsylvania.

610 College graduate, preferably one who has been out two or three years and acquired a little business experience or acquaintance with business methods, would be employed principally in demonstrating and selling mine rescue apparatus, various styles of reviving apparatus employing artificial respiration and kindred devices; will be expected to make occasional trips to the various coal fields, but would be located at New York office the greater part of the time. Man who has studied elementary chemistry and who is something of a mechanic.

611 Salesman for Eastern states, for thermo-dynamic apparatus as feed water heaters, oil and air coolers, and air heaters; also for condenser line. Location probably in Boston.

612 Instructorship in mechanical engineering department of university in Pennsylvania; prefer man with at least one year's outside experience. Salary $900 to $1000.

613 Vacancy in the mechanical laboratory division of university in Pennsylvania; salary $1400 to $1500. Applicant should have had both outside and teaching experience.

614 Wanted, mechanical engineer thoroughly familiar with shop practice, resourceful in design and manufacture, familiar with the fundamental principles of scientific management, capable of taking charge of a small factory of fifteen men manufacturing mathematical instruments; would be expected to start as draftsman until familiar with the work; only those of good managing ability and push need answer. Give full particulars and references. State salary required to start. Location, Pennsylvania.

617 General manager for sawmill and timber company in North Carolina; does not need to be an engineer but capable of handling large enterprise. Large tract of timber is owned and 50,000 feet or more of timber handled daily. Apply by letter.

620 Successful company manufacturing light machinery desires to add one or more new products and will take over the manufacture and sale of any device that has proven its merit and for which there is a wide market. Name confidential. Apply by letter.

621 Contractor wanted to saw out lumber from large tract in North Carolina. Sales will be arranged. Apply by letter.

MEN AVAILABLE

G-700 Member, thoroughly familiar with the design of gas producers, gas engines from 50 h.p. to 300 h.p. and Corliss engines for all purposes, such as pumping, blowing and hoisting engines, air compressors and power plants, desires position as mechanical engineer or assistant mechanical engineer.

G-701 Student member, technical graduate with gas engine experience, desires position in some gas engine line where advancement may be obtained. At present in charge of care, maintenance and operation of various gasolene engines on large construction job. Would start at $100 per month.

G-702 Member located in Norway desires to act as representative of American firms.

G-703 Mechanical engineer, technical graduate, S.B. and M.M.E., with practical training and executive experience as superintendent with large corporations in steel and automobile business, owing to acute depression of motor truck industry, desires position as superintendent or manager of a plant manufacturing a good line of mechanical product. Location immaterial.

G-704 Member, technical graduate, with 13 years successful teaching experience, will be open for position in September as instructor of mechanical drawing and machine design and related subjects, or as superintendent of shops in an engineering college or university. Would also consider position as director or head of department of a vocational or trades school. Can handle several lines of shop work in both wood and metal.

G-705 Member, age 33, technical graduate, experienced as chief draftsman and as manager of engineering and drafting departments in manufacturing lines desires similar position, or position as mechanical engineer, or assistant to superintendent or manager.

G-706 Pennsylvania State College graduate, degrees B.S. and M.E., age 31, married, with four years shop experience and five years varied engineering teaching experience, desires a position as instructor in the mechanical engineering department of a college. At present teaching.

G-707 Member, age 38, ten years experience in charge of shops and departments, desires position as superintendent or foreman, or practical machinist. Competent to organize; thoroughly familiar with all modern manufacturing methods and systems. Location immaterial.

G-708 Mechanical engineer with technical education, age 30, thorough training in power plant and locomotive testing, desires position as mechanical engineer with large industrial corporation to take charge of power plants, equipment, etc. Past four years connected with architect's office as mechanical engineer in designing power plants, heating, ventilating, electrical and plumbing installations for office buildings, factories and large schools.

G-709 Member, age 32, at present designing special heavy machinery. Has had varied and valuable experience in same and in mill construction; original and practical ideas in design gained by ten years field and office experience. Wishes to connect with company desiring services of capable engineer, superintendent of erection or inspector. Location secondary consideration. Minimum salary $2400.

G-710 Member, age 33, married, at present employed as inspector of mechanical equipment in addition to large power station, desires position as assistant superintendent of power in large generating station, or with large engineering firm designing or erecting power stations. Has had six years experience designing and erecting power houses for industrial plants and railroads.

G-711 Mechanical engineer, technical graduate with 15 years shop and mill experience desires important position as plant engineer, or would consider taking an interest with services in small manufacturing enterprise turning out mechanical goods.

G-712 Technically trained man with shop experience and an extensive record at designing presses, dies and other sheet metal tools, special automatic machines, and machine tools for special purposes, desires employment along these lines.

G-713 Member, technical graduate, with experience in executive work of large corporations, desires position as works manager or superintendent. Wide training and experience in the items which are required of a corporation engineer, such as the design of power plants and machinery, their construction, maintenance and operation, purchasing engineering material, taking executive charge of all consulting work including building construction of all kinds.

G-714 Technical graduate, 37 years of age, 15 years wide experience in teaching manual training, mathematics, drawing and machine design and mechanical engineering subjects, desires a position with broader outlook. Would accept position in a technical high school, industrial school or college as director or head of department.

G-715 M. I. T. graduate, with experience on instructing staff and in efficiency engineering and scientific management in power, manufacturing and auxiliary departments, desires further work along these lines, or permanent executive position with concern desiring energy and ability.

G-716 Associate, age 36, railroad and valuation experience with five large companies; also in mechanical and electrical equipment other than rolling stock and structures. Competent to serve with construction company, or as works or purchasing engineer.

G-717 Junior, ten years practical experience, consulting mechanical engineer with office in Philadelphia, wishes to arrange with a company in that vicinity for part time.

G-718 Graduate M.E., executive, desires position where wide engineering knowledge will be of value. Has served as assistant vice-president and secretary of well known manufacturers of machinery. Duties included sales, advertising, development of new ideas and general office management.

G-719 Member, age 40, mechanical engineer, going to Europe for summer, would assume duties of engineering or commercial nature for firms desiring representative; wide experience in design, manufacture and sales of mechanical and electrical equipments of power and industrial plants, hoisting, conveying and special machinery, motor cars. Fluent knowledge of German, Swedish and Danish, well acquainted with engineering trade conditions and market requirements in Northern Europe. Would consider permanent engagement as foreign representative for reliable concern.

G-720 Mechanical engineer, with ten years experience as draftsman, designer, engineer and superintendent in marine engines, hoisting and conveying machinery, cement machinery and plants, general manufacturing and repair work.

G-721 Junior, age 31, married, foundry assistant superintendent or engineer, with 13 years experience in shop, drawing room and foundry, last four years specializing in foundry efficiency work, installation and operation of equipment. Designer of successful molding machinery, pattern mounting methods, etc.; understands melting and mixing of gray iron, malleable and crucible steel. Capable executive, organizer and investigator.

G-722 Stevens graduate, nine years practical experience on construction and electrical work, also sales experience; wide acquaintance among engineers, architects and builders.

G-723 Junior, age 38, sales engineer, experienced in handling high-grade power transmission and mechanical specialties, desires to represent manufacturer; eastern United States or England preferred.

G-724. Junior, graduate mechanical engineer, age 26, with three years shop and drafting room experience in locomotive construction, desires position with engineering or manufacturing company. Location immaterial.

G-725 Member, mechanical engineer, age 42, married, desires position in which good future can be expected; 14

years experience in drafting, designing, supervising and executive positions, power plant work, heating, ventilating, mill engineering and factory.

G-726 Mechanical engineer, 14 years experience on steam station design and construction, with positions as chief draftsman, resident engineer and superintendent of construction; lately completed the installation of a 7500-kw. turbine condensing plant in Canada. Location immaterial but prefer to connect with New York concern. Can invest some money if desired.

G-727 Junior, age 26, experience in design, construction and operation of steam engines, boilers, refrigerating machinery and power plant accessories; recently employed on hydraulic dredging machinery and pumps.

G-728 Mechanical engineer, age 38, married, 14 years experience in design, construction and operation, wishes position with cement manufacturing company; recently superintendent of a 3000-bbl. plant; salary moderate.

G-729 Graduate University of Cincinnati, age 24, four years experience as machinist, foundry experience, and one year experience in power plant construction and design, would consider position with good chance for advancement, or as instructor in engineering or technical school. Location immaterial.

G-730 Junior, age 27, married, efficiency expert, graduate mechanical engineer, unusual experience in industrial organization methods, desires better opportunity. At present employed.

G-731 Member, technical graduate, at present and for several years past engaged in successful practice as consulting engineer, especially experienced in power requirements and equipment for mining and contracting operations, would consider regular employment with substantial concern; willing to accept smaller prospective compensation in return for greater regularity.

G-732 Student member, technical graduate, desires position in mechanical engineering line, preferably in gas engineering field; can furnish best references.

G-733 Works manager or superintendent, age 36, graduate mechanical engineer with broad experience in factory work; have been especially successful in designing machinery for interchangeable manufacture and organizing men to get best results. At present superintendent of factory employing 800 men, but desires change.

G-734 Graduate mechanical engineer with 18 years experience as draftsman, checker, designer, estimating and selling engineer for various kinds of gridiron and Corliss engines, crank and flywheel pumping engines, air compressors and special machinery, desires position as chief draftsman, selling or estimating engineer or office manager; thoroughly acquainted with modern shop methods of manufacture.

G-735 Associate-Member, mechanical engineer, age 29, nine years experience gas engine design, four years gas traction engine development, extensive carburetor design, desires position as designing engineer or superintendent of experiments; can develop complete motor for use of kerosene or other low grade fuel.

G-736 Associate-Member four years practical shop and office experience in all departments of well known company, desires to locate permanently with a first class concern as sales manager or factory superintendent.

G-737 Commercial engineer, M.E. 1904, Associate-Member, knowledge of five languages, invites correspondence for position where tact with engineering skill will be appreciated.

G-738 Energetic young man, age 21, graduate M.E. 1914, unmarried, desires to enter commercial field with manufacturing concern; have had some business experience; location immaterial.

PERIODICALS WANTED

Following is a list of periodicals which the Library of the Engineering Societies desires to obtain in order to complete its list of reference sets. Anyone having any of the missing numbers will confer a favor by communicating with the librarian, W. P. Cutter, 29 West 39th Street, New York.

Acetylene Journal. 1-13, 1899-1912.
Acetylen in Wissenschaft und Industrie. 1-12, 1898-1909.
Acetylene. 1-5, 1903-1908.
Aëronautical Journal. 1-12, 1897-1908.
Allgemeine Automobil Zeitung. 1-9, 1900-1908 (Berlin).
Allgemeine Bauzeitung. 1-date, 1836-date.
American Lumberman. 1-date, 1899-date.
Annalen der Chemie (Liebig's). 1-364, 1832-1909.
Annales des Mines Belgique. 1-8, 1896-1903.
Annales des Ponts et Chaussée. Memoires et documents. Ser. 1-5; Ser. 6, vols. 1-16, 19-end of ser.; Ser. 7; Ser. 8, vols. 1-30, 36.
— Lois decrets, etc. Ser. 1-5; Ser. 6, vols. 1-8, 10-end of ser.; Ser. 7; Ser. 8, vols. 1-7, 8 pt. 1.
— Personnel. All before 1889, and any issued to date.
Annales des Travaux Publics de Belgique. 1-date, 1843-date.
Archiv für Eisenbahnwesen. 1-30, 1878-1907.
Autogene Metallbearbeitung. 1-date, 1908-date.
Berg und Hüttenmannische Zeitung. Vols. 1-21; 44, no. 36; 49, no. 14, 45, 51; 50, nos. 8, 47; 51, no. 19; 52, nos. 39, 41; 42, 44-52; 54, nos. 2, 3, 4, 25, 26, 29, 30, 32; 55, no. 10.
Beton und Eisen. 1-2, 1902-1903.
Braunkohle. 1-7, 1902-1908.
Brick. 1-42, 1894-1913.
Cement and Engineering News. 1-21, 22, no. 2, 1896-1909, 1910.
Centralblatt der Bauverwaltung. 1-33, 1881-1913.
Chemical Engineer. 1-4, 1904-1906.
Chemical Society of London. Journal. 1-26, 1849-1873.
Chemiker Zeitung. 1-10, 12, 1877-1886, 1888.
Chemische Industrie. 1-date, 1878-date.
Chemisches Centralblatt. 1-date, 1830-date.
Ciment (Paris). 1-date, 1896-date.
Connecticut Society of Civil Engineers. Papers. 1-25, 27, 1894-1909.
Contractor (Chicago). 1-date, 1898-date.
Deutsche chemische Gesellschaft, Berichte. 1-6, 1868-1873.
Eisen Zeitung. 1-24, 1880-1903.
Electrician. Ser. 1, vol. 19 to end of series, 1886-1890.
Elektrische und Maschinelle Betriebe (Leipzig). 1-date, 1898-date.
Elektrochemische Zeitschrift. 1-8, 1894-1901.
Elektrophysikalische Rundschau. 1-3, 1910-1912.
Elektrotechnische Nachrichten. 1-date, 1905-date.
Feuer und Wasser. 1-date, 1894-date.
Fonderie Moderne. 1-4, 1908-1911.
Gas World. 1-58, 1884-1913.
Gazetta chimica Italiana. 1-date, 1871-date.
Geographical Journal. 33-date, 1908-date.
Geological Magazine. 4 to new ser. decade, 5, vol. 5, 1867-1908.
Geologisches Zentralblatt. 1-11, 1898-1908.
Gesundheits Ingenieur. 1-31, 1878-1908.
Glückauf. 1-31; 36, no. 27; 38, nos. 2, 7, 1865-1902.
Gummi Zeitung. 1-21, 1888-1906.
Haeder's Zeitschrift für Maschinenbau. 1-20, 1893-1912.
Helios. 1-date, 1895-date.
Houille Blanche. 1-10, 1902-1911.
Ingenieur (The Hague). 1-24, 1886-1902.
Institute of Marine Engineers. 1-20, 1889-1909.
Institution of Engineers and Shipbuilders in Scotland. 1, 8, 1857, 1865.

Iron Age. 1-23, 1855-1878.
Jern Kontortes Annaler. 2, 4, 13, 16, 17, 19, 20. New Ser. 1, pts. 1-2; 3; 5-11; 12, pt. 5-end of vol.; 14-15; 28, pts. 1-3, 6-end of vol.; 29, pts. 1-2, 4-5; 30, pt. 2; 31, pts. 2-5; 54, pt. 1; 63, pts. 3-4, 1818-1908.
——— Bihang. All before 1828, 1829-1836, 1838-1867, 1869-1899.
——— Register. 1817-1890.
Journal für Gasbeleuchtung. 1-51, 1858-1908.
Journal für Praktische chemie. 1-date, 1828-date.
Journal of Gas Lighting. 1-22, 51-52, 56, 62-63, 93, 96, 99-108, 1850-1909.
Koninklijk Instituut von Ingenieurs (Hague). Tijdschrift. 1870-1903, 1906.
Marine Engineer and Naval Architect. 1-25, 1879-1903.
Metallröhren Industrie. 1-date, 1907-date.
Metallurgie (Paris). 1-32, 37, 40, 1868-1909.
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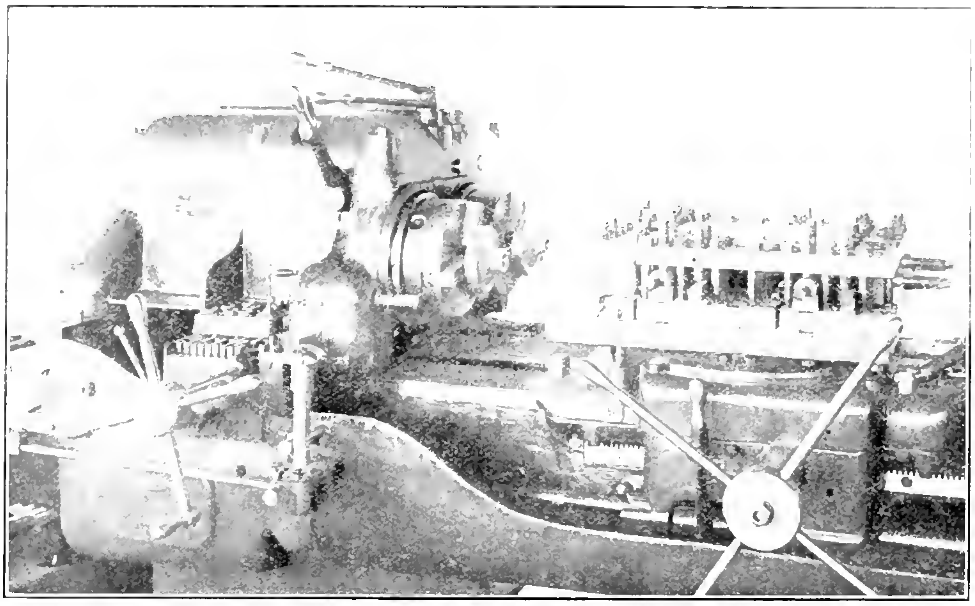
Armour Inst. of Tech.	Mar 9, 1909	G. F. Gebhardt	F. L. Brewer, Jr.	J. A. Agee Armour Inst. of Tech., Chicago, Ill.
Carnegie Inst. of Tech.	Oct 14, 1913	W. Trinks	J. B. Patterson	W. M. Sheldon 5137 Woodlawn Ave., Pittsburgh, Pa.
Case School of Applied Science	Feb 14, 1913	F. H. Vose	H. C. Mummert	J. B. Whitacre Case School of Applied Science, Cleveland, O.
Columbia Univ.	Nov 9, 1909	Chas. E. Lucke	H. F. Allen	A. S. Henry 333 Central Park W., New York, N. Y.
Cornell Univ.	Dec 4, 1908	R. C. Carpenter	J. G. Miller	D. S. Wegg, Jr. 16 E. Ontario St., Chicago, Ill.
Kansas State Agri. College	Feb 13, 1914	A. A. Potter	V. Whiteside	J. I. Michaels P. O. Box 125, Manhattan, Kan.
Lehigh Univ.	June 2, 1911	P. B. de Schweinitz	A. V. Bodine	H. A. Brown Lehigh Univ., South Bethlehem, Pa.
Leland Stanford Jr. Univ.	Mar 9, 1909	W. F. Durand	J. A. Gibb	C. L. Addleman 219 Ramona St., Palo Alto, Cal.
Mass. Inst. of Tech.	Nov 9, 1909	E. F. Miller	F. G. Purinton	H. E. Morse Box 233, East Bridgewater, Mass.
New York Univ.	Nov 9, 1909	C. E. Houghton		
Ohio State Univ.	Jan 10, 1911	Wm. T. Magruder	R. D. Rogers	W. W. Watson 153 W. 8th Ave., Columbus, O.
Penn. State College	Nov 9, 1909	J. P. Jackson	C. F. Kennedy	D. E. Hewitt 412 Main Bldg., State College, Pa.
Poly. Inst. of Brooklyn	Mar 9, 1909	W. D. Ennis	M. Van Valkenburgh	Samuel Kobre Poly. Inst. of Brooklyn, Brooklyn, N. Y.
Purdue Univ.	Mar 9, 1909	G. A. Young	S. A. Peck	T. S. Tulien 216 Fillmore St., Topeka, Kan.
Rensselaer Poly. Inst.	Dec 9, 1910	A. M. Greene, Jr.	F. E. McMullen	R. L. Manier 90 Walnut St., Binghamton, N. Y.
State Univ. of Iowa	Apr 11, 1913	R. S. Wilbur	L. A. White	H. C. Doane Newton, Ia.
State Univ. of Kentucky	Jan 10, 1911	F. P. Anderson	H. G. Strong	R. T. Thornton R. R. I., Lexington, Ky.
Stevens Inst. of Tech.	Dec 4, 1908	Alex. C. Humphreys	L. F. Bayer	C. H. Colvin 56 N. Maple Ave., East Orange, N. J.
Syracuse Univ.	Dec 3, 1911	W. E. Ninde	G. T. Parsons	W. J. Campbell 303 Waverly Ave., Syracuse, N. Y.
Univ. of Arkansas	Apr 12, 1910	B. N. Wilson	M. McGill	C. Bethel Univ. of Ark., Fayetteville, Ark.
Univ. of California	Feb 13, 1912	Joseph N. LeConte	A. C. Moorhead	H. L. McLean Univ. of Cal., Berkeley, Cal.
Univ. of Cincinnati	Nov 9, 1909	J. T. Faig	J. Dollman	A. J. Langhammer 713 Crescent Ave., Covington, Ky.
Univ. of Colorado	Apr 10, 1914	P. S. Rattle	L. J. Brady	S. S. Cooke 1290 Race St., Denver, Colo.
Univ. of Illinois	Nov 9, 1909	W. F. M. Goss	C. R. Velzy	E. F. Gehrig Univ. of Illinois, Urbana, Ill.
Univ. of Kansas	Mar 9, 1909	F. H. Sibley	L. C. Angevine	H. L. Newby 1501 Rhode Island St., Lawrence, Kan.
Univ. of Maine	Feb 8, 1910	Arthur C. Jewett	E. E. Fowler	A. B. Hayes S. A. E. House, Orono, Me.
Univ. of Michigan	Apr 10, 1914	John R. Allen	R. H. Mills	C. H. McClellan 928 Oakland Ave., Ann Arbor, Mich.
Univ. of Minnesota	May 12, 1913	J. J. Flather	A. Buenger	J. L. Hartney 1724 Fourth St., S. E., Minneapolis, Minn.
Univ. of Missouri	Dec 7, 1909	H. Wade Hibbard	F. A. Heileman	F. H. Frauens 212 E. 35th St., Kansas City, Mo.
Univ. of Nebraska	Dec 7, 1909	J. D. Hoffman	A. A. Luebs	G. W. Nigh c/o G. W. Nigh, Sr., Havelock, Neb.
Univ. of Wisconsin	Nov 9, 1909	H. J. Thorkelson	M. A. Cook	R. E. Maurer c/o The Utah Gas & Coke Co., Salt Lake City, Utah.
Washington Univ.	Mar 10, 1911	E. L. Ohle	A. O. Schleiffarth	J. A. Watkins, Jr. 5803 Michigan Ave., St. Louis, Mo.
Yale Univ.	Oct 11, 1910	L. P. Breckenridge	L. F. Harder	M. C. Corbett 288 Orchard St., New Haven, Conn.



Facts and Figures

Let us get beneath the surface and see just what counts in Turret Lathe construction. Is it weight, ponderous looks, complicated mechanism, salesmanship, or something else?

The question frequently pops up when a new Turret Lathe is under consideration—"Why are the *Jones & Lamson Turret Lathes* so popular, and *why* are they used so extensively by the big Railroads, Automobile Plants—in fact, in most every plant that uses Turret Lathes for quality and quantity production?

We recently received a letter from the Foreman of the Manufacturer who purchased the first Double Spindle Turret Lathe, and, incidentally, has since purchased five more of the same type.

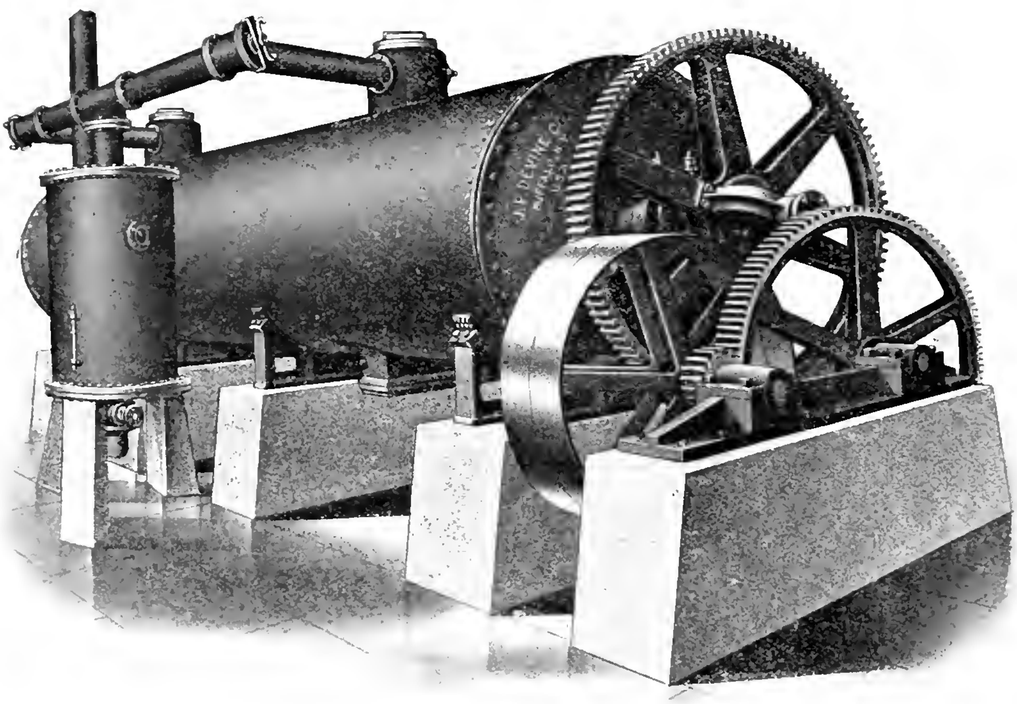
Quoting the foreman: "Your Double Spindle Flat Turret Lathe was put in operation in less than one month after receipt here, and used constantly ever since (covering a period of more than three years) machining gears.

"Its present average is 150 finished gear blanks every 9 hours. The feed is changed 3 *times* per gear, or 450 times per day, and the only attention given the feed mechanism to date was an occasional supply of oil. Not one part has ever been removed."

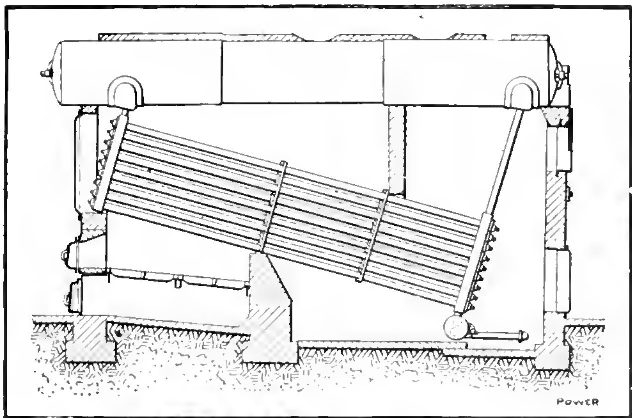
Now let us assume that the number of work days per year is three hundred. One does not require a knowledge of *differential calculus* to arrive at the exact figures covering the changes—and where, and under what conditions would you find a more severe test on the feed mechanism?

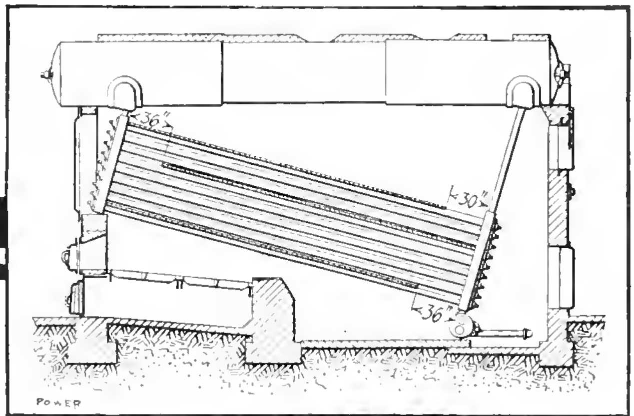
Is it not evident that the construction and workmanship must be as near perfect as is possible to produce?

Look at the illustration on the next page showing the *feed controlling lever* and the slight movement required for any of the nine changes of feed, ranging from 20 to 120 per inch. The illustration shows the lever in both positions.



COMPARE THESE BOILERS





THE comparative efficiency of the same boiler when set with vertical cross baffling and re-arranged for horizontal baffling is given fully in a paper by Henry Kriesinger and Walter T. Ray, Western Society of Engineers, June 2, 1913, and the Journal, Am. Soc. M. E., January 1914.

The first boiler shows an efficiency of 61.3% with Pocohontas coal and 60.9% with Clinchfield.

The second boiler, with the horizontal baffling, showed 63.6% with Pocohontas and 67.2% with the Clinchfield.

Furthermore, the draft drop through the boiler with the vertical cross baffling at 128% load was ½ inch, whereas with the horizontal at 127% load, the draft drop was ⅜ inch, with the same per cent. CO_2.

The horizontal baffling shown above is exactly the same as used in all large Heine Boilers. There is a tile roof over the furnace and two horizontal passes for the gases through the boiler.

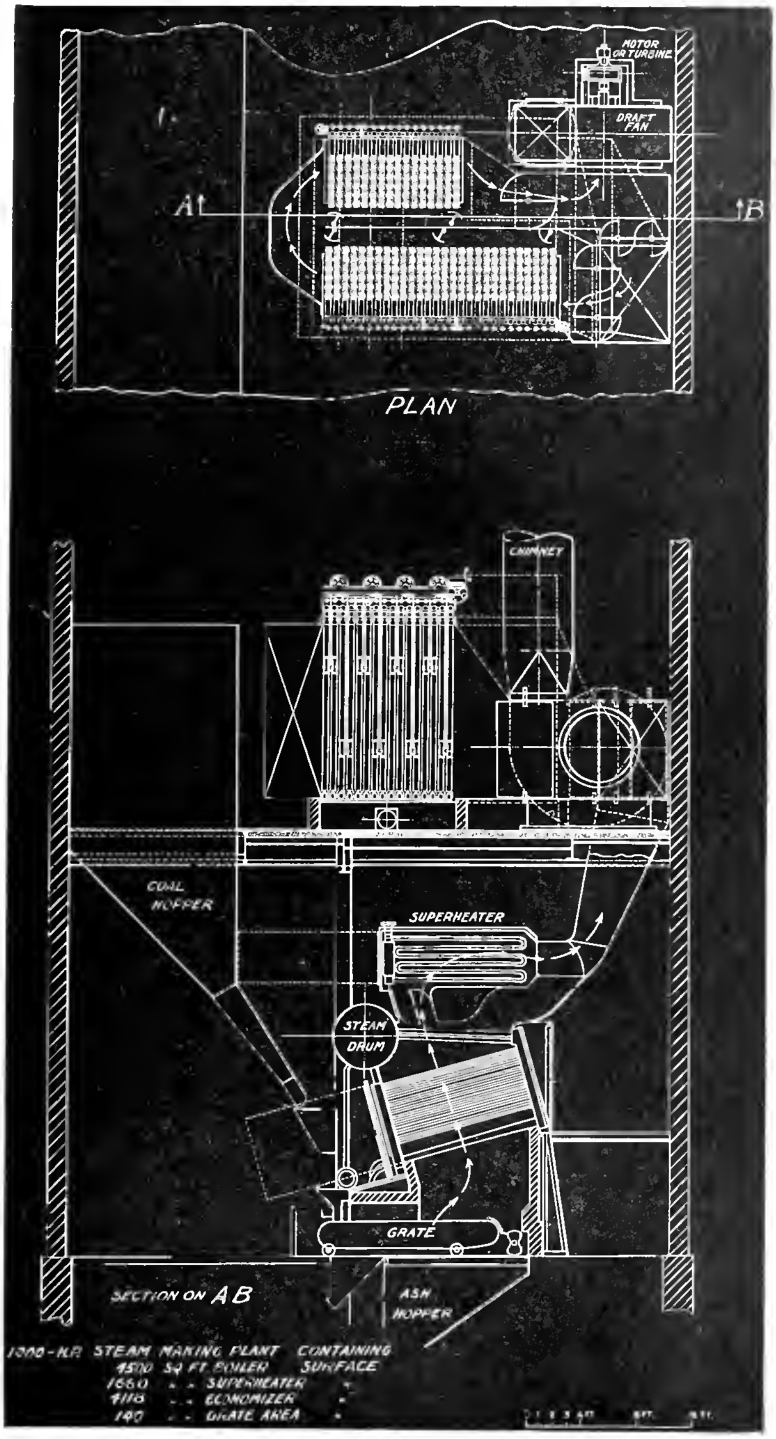
NOWADAYS
IT'S
HEINE

Ask for our pamphlet on large Heine Boilers also a test of a two-pass 635 H. P. Boiler at the Grand Central Terminal, New York.

HEINE SAFETY BOILER CO.
2465 E. Marcus Ave., St. Louis, Mo.

GREEN'S ECONOMIZER

Is Essential in the Modern Steam Plant



MORE steam can be produced from less fuel and at less total cost by means of Green's Economizer.

Boiler surface should be used only for transferring the heat of evaporation, the water being brought up nearly to the boiling point and more advantageously by the economizer surface.

The Economizer is able to extract more heat from the gases than could the boiler surface, no matter how far extended, since the economizer contains water at hot well temperature, whereas the boiler contains water at a temperature corresponding to the steam temperature, that is, nearly 300° hotter. As the flow of heat from the gases to the water is proportional to the difference in temperature, a square foot of economizer surface abstracts heat from the gases much more actively than would a square foot of boiler surface located at the same point in the travel of the gases.

By omitting that part of boiler surface, which is comparatively ineffective in the recovery of heat, and by placing an economizer on the floor above the boiler, economies of ground space and building, as well as of fuel and apparatus, are realized. An illustration of this arrangement is shown in the above drawing.

For many other interesting examples of modern steam plant design, send for our 100-page book, ME No. 142.

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Matteawan, N. Y.

New York City, Boston, Chicago, Atlanta, San Francisco, Los Angeles, Seattle, Salt Lake City, Montreal.

Engineers: Builders of Green's Fuel Economizers, Fans, Blowers and Exhausters, Steam Air Heaters, Coils, Waste Heat Air Heaters, Mechanical Draft, Heating and Ventilating and Drying Apparatus, Draft Dampers and Engines.

There's Profit in The Summer Lull

During the sweltering summer days, when the thermometer sizzles around the nineties; when everybody lets up; when profits go down, but overhead stays where it is—that's the time to make profits bigger for the busy fall and winter. You can best afford, during the slack season, to install

"Sells" Roller Bearings

the dependable *all-split* line-shaft bearings, that *interchange* with plain bearing boxes. If you install them now, or later in the summer, you will be drawing profit out of the low-profit summer months—the lull time of the year—by preparing for a lower power expense as soon as business picks up. The thousands of "Sells" Bearings in use are your best guarantee of the service that you'll be building into your plant. Write today. Catalog?

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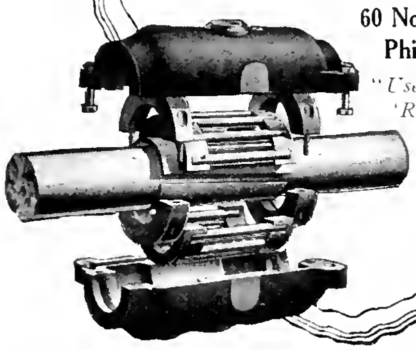

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Let us build your special machine, or furnish you with machine work on a contract basis, in our large, up-to-date factory. Our forty years' experience in building special machines for knitting mills, paper making, wood working and nearly every other kind of purpose is sure to be of service to you.

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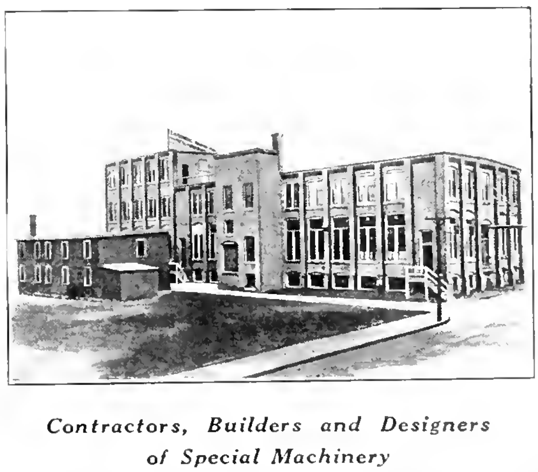

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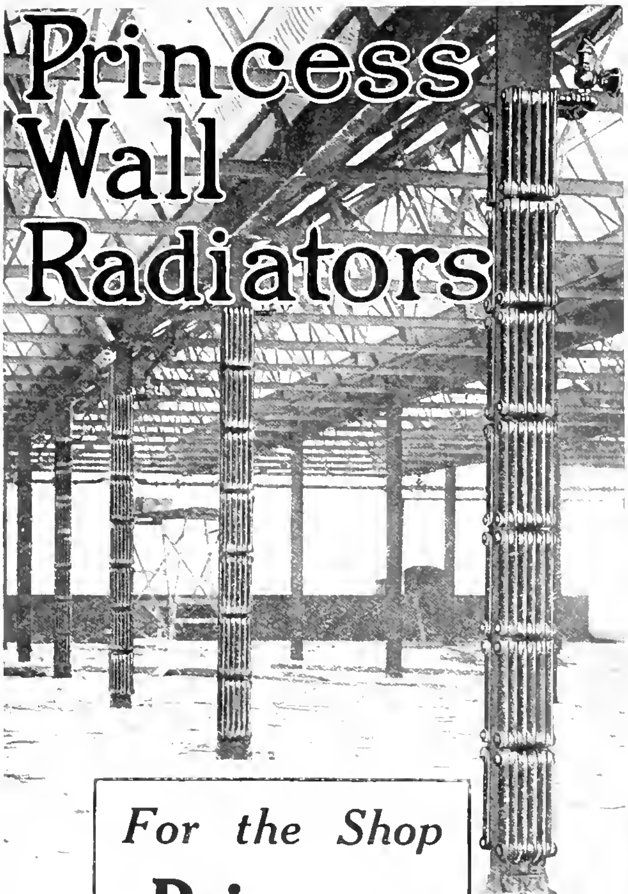
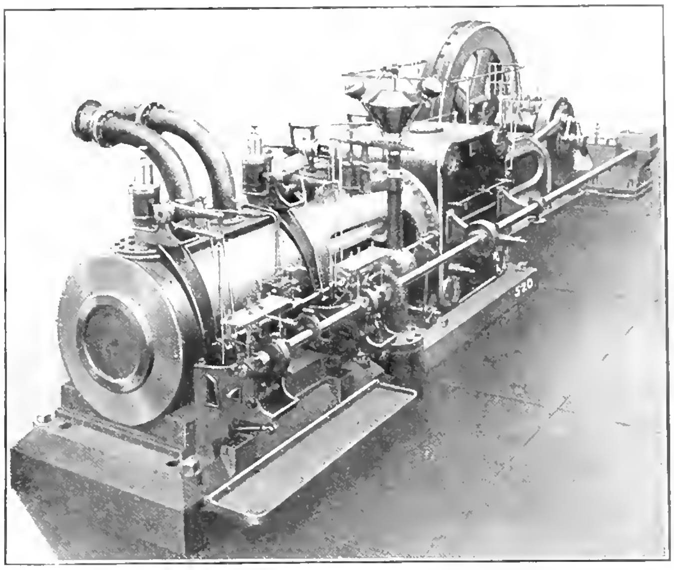
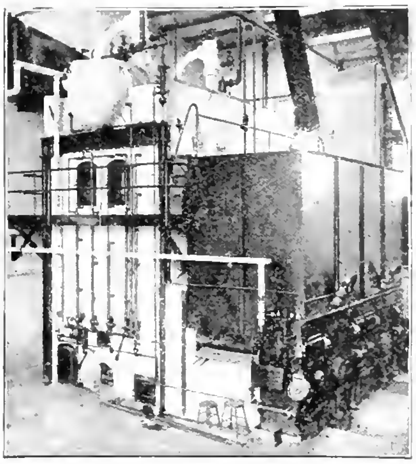

Princess
Wall
Radiators



See the Recognition Afforded

VULCAN SOOT CLEANERS

DURING MAY, 1914



Vulcan Soot Cleaner in use at General Electric Co. Lamp Works, St. Louis, Mo. Plants at Schenectady, Cleveland, Minneapolis, and Central Falls, R. I., also use THE VULCAN.

(VULCAN SYSTEM Shown on Side of Boiler.)

SOLVAY PROCESS CO., SYRACUSE, N. Y.
5-2365 H.P. Cleaners for Stirling Boilers. 10 Cleaners for Sturtevant Economizers.

PENNSYLVANIA SALT MFG. CO., WYANDOTTE, MICH.
15-300 H.P. Cleaners for B. & W. Boilers.

AMERICAN SHEET & TIN PLATE CO., PITTSBURGH, PA.
3-300 H.P. and 1-400 H.P. Cleaners for Stirling Boilers.

STONE & WEBSTER ENGINEERING CORP., BOSTON,
FOR NORTHERN TEXAS TRACTION CO., HANDLEY, TEXAS
6-600 H.P. Cleaners for B. & W. Boilers.
FOR EL PASO ELEC. RY. CO., EL PASO, TEXAS
6-600 H.P. Cleaners for B. & W. Boilers.

BYLLESBY & COMPANY, CHICAGO
FOR LOUISVILLE GAS & ELEC. CO., LOUISVILLE, KY.
4-500 H.P. Cleaners for B. & W. Boilers.

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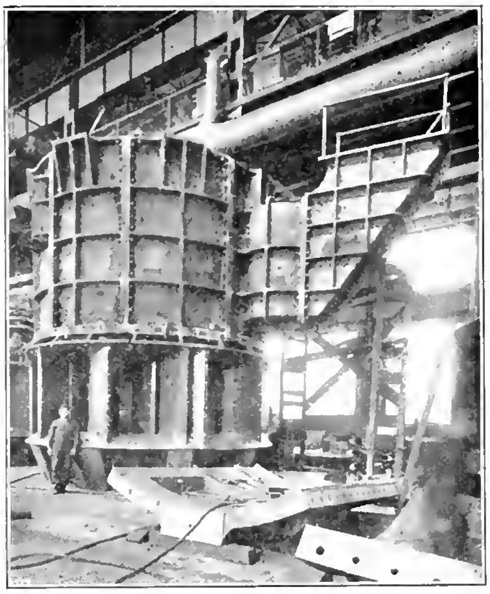
Specialists in the Design and Construction of High Class, High Power, and High Efficiency Hydraulic Turbines

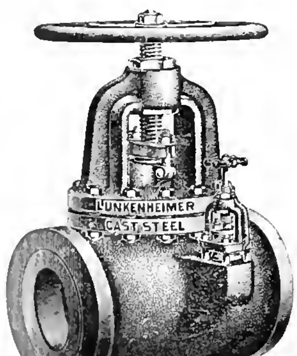
Illustration shows one of six turbines designed and built for the Laurentide Company Ltd., Grand Mere, P. Q., Canada. Unit is of the single runner, vertical shaft type, with cast iron pit liner. Volute casing and draft tube are formed in the concrete.

The I. P. Morris Company have built or have under construction turbines of this type aggregating 472,700 horse-power.

Inquiries for turbines requiring special design will be given every attention.



20,000 H. P. TURBINE
Head 76 feet. Speed 120 R. P. M.
Most powerful Turbines of this Type ever built



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Lunkenheimer line of Cast Steel Valves consists of Globe, Angle, Cross, Gate, Throttle, Non-return Boiler Stop, etc., made in all standard sizes and two combinations as regards the materials used for the trimmings, in order to meet various conditions of pressure and superheat. Also made in **"Puddled" Semi-steel.**

All of the above, together with Check, Lever, Pop Safety, Relief, Blow-off, Screw Down Check Valves, etc., are furnished in **Bronze** or **Iron Body Bronze Mounted.**

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Your local dealer can furnish them; if not, write us.

A complete description of the entire line can be had by referring to Lunkenheimer No. 50 Catalogue. Write for a copy.

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"QUALITY"

Largest Manufacturers of High Grade Engineering Specialties in the World

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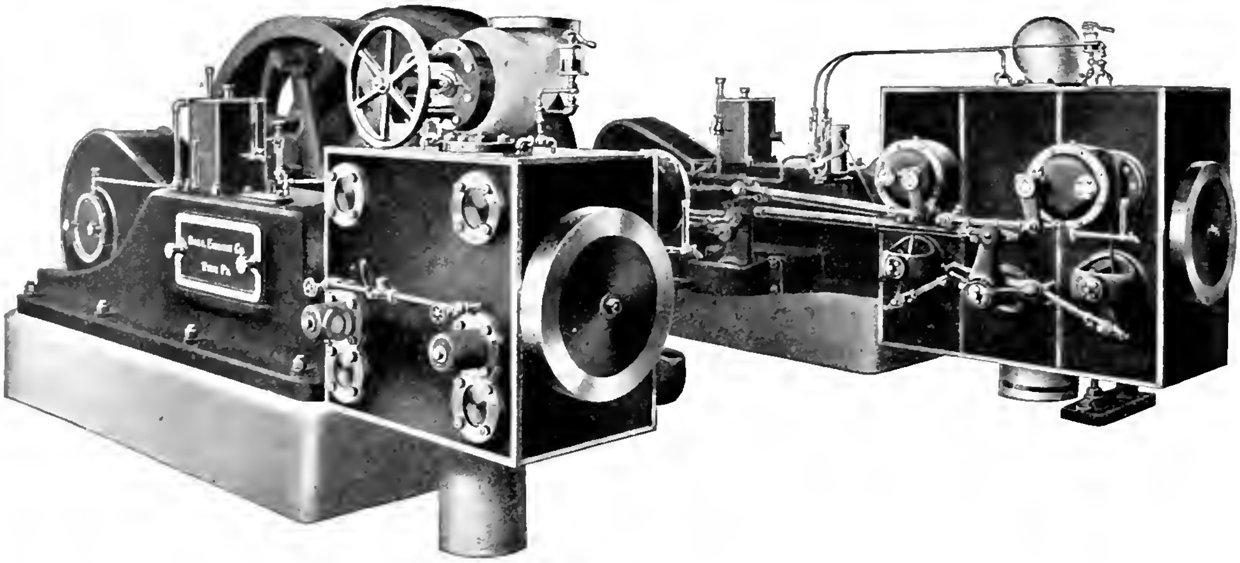

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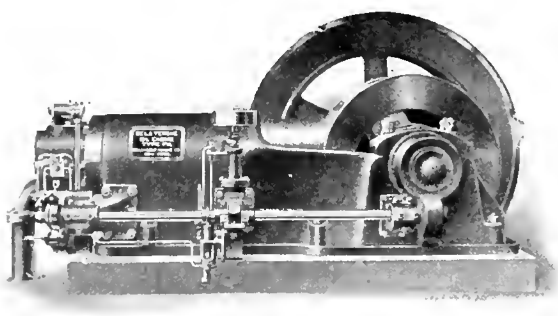


TYPE FH OIL ENGINE

Send for Bulletin No. 132

Have been developed over a period of twenty years in the United States to meet American conditions.

Heavy Mexican crude oil with sulphur up to 3½% is the cheap American fuel.

Specially trained operating engineers are expensive. The De La Vergne engine has been highly developed and will burn this cheap fuel and operate with only ordinary attention.

We guarantee when operating at three-quarters or full load a fuel consumption of one-half pound ($\frac{1}{16}$ of a gallon) per Brake Horse Power Hour of any commercial fuel or crude oil produced in the United States or Mexico.

The economy, the ability to burn the heaviest fuels and the simplicity of the De La Vergne engine make it the ideal source of power for factory service, electric installations, ice plants and isolated stations of every description.

We build engines from 12 to 800 H. P.

As many as eight successive orders comprising forty-two engines in all, have been placed by a single customer for his own use—proof positive of satisfactory service.

De La Vergne Machine Company

1123 E. 138th Street **New York City**

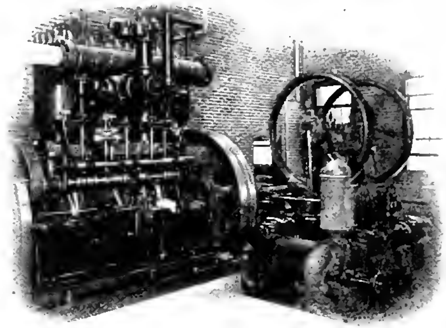
65 Years in the Pump Business

Has given us valuable experience in solving pumping problems of every kind. This experience is at the disposal of engineers when planning equipment for any service.

As the largest manufacturer of pumps for every purpose, we are in a unique position to be of assistance to you.

We have issued for engineers a series of bulletins giving complete data on all types of Goulds Power Pumps.

Send for a complete set.



Goulds Gas Engine-driven Triplex Pump in the Manchester, Mass., city water works. This equipment reduced pumping costs more than two-thirds over that with the equipment previously used.

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NO VALVE GEAR —— NO ADJUSTMENTS

MESTA AUTOMATIC PLATE VALVES (IVERSEN PATENT) MAKE POSSIBLE MUCH HIGHER PISTON SPEEDS THAN WERE HERETOFORE USED. THEY DO IT WITH INCREASED ECONOMY AND RELIABILITY.

THE MESTA MACHINE COMPANY IS EQUIPPING EXISTING COMPRESSORS OF VARIOUS MAKES WITH AUTOMATIC PLATE VALVES OR WITH NEW AIR HEADS CONTAINING THEM.

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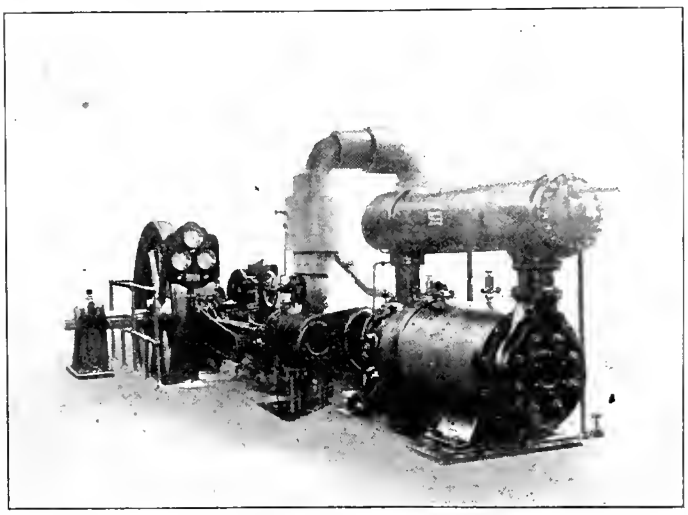

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WORKS: MESTA STATION, P. R. R., WEST HOMESTEAD, PA.

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Oil and Steam Engines

Are Backed by Our Reputation for Reliability
"Sixty Years of Successful Manufacturing"

We build our machinery complete in our own plant. Long experience has demonstrated the proper materials to be used in our castings and our workmanship is of the highest class.

Fulton-Tosi Oil Engines, Diesel Type

Fulton-Corliss, Medium and High Speed Engines

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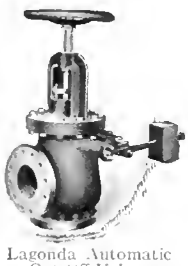
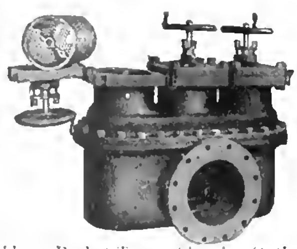
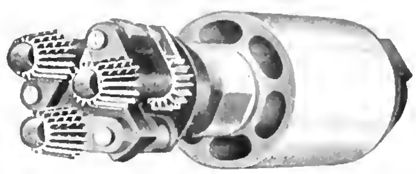


Lagonda Automatic Cut-Off Valve.



Three Basket Type—Showing Outlet and One Basket Removed.



Quick Repair Head, Water Turbine Tube Cleaner.

(1) Pressures are high (2) Sudden overloads occur

(3) Loads are higher

(4) Plants require a constant supply of cooling water

(5) Tubes become scaled more rapidly

These conditions demand a greater insurance for safety, high economy, and continuous operation.

For continuous operation at full rating condensers must have a constant supply of cooling water. **A Lagonda Multiple Water Strainer** placed in your water supply main will collect all foreign matter, such as sticks, ice, leaves, etc., where they can be quickly and easily removed, and prevent their clogging the condensers and pumps.

The Lagonda Cut-Off Valve automatically cuts out boilers in which a tube has ruptured or drawn, and thus prevents the spreading of the disturbance to the remainder of the plant. It also cuts out the boiler in case of a header rupture or troubles beyond the boiler. It automatically cuts boilers into the line when at the proper pressure and absolutely prevents the turning of steam into a cold boiler when it is down for cleaning or repairs.

Weinland Tube Cleaners are made for all conditions and drives. They are simple, durable, easily and quickly repaired.

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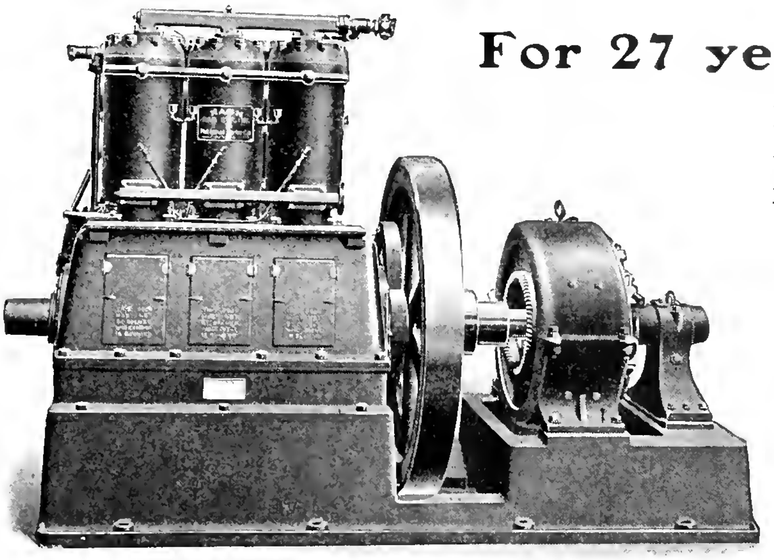
SPRINGFIELD, OHIO
FUEL SAVING SPECIALISTS

NEW YORK, BOSTON, PHILADELPHIA, ST LOUIS, CHICAGO, DETROIT — DALLAS, SAN FRANCISCO, ST. PAUL, MONTREAL, LONDON

THE NASH ENGINE



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and high grade
Power Plants

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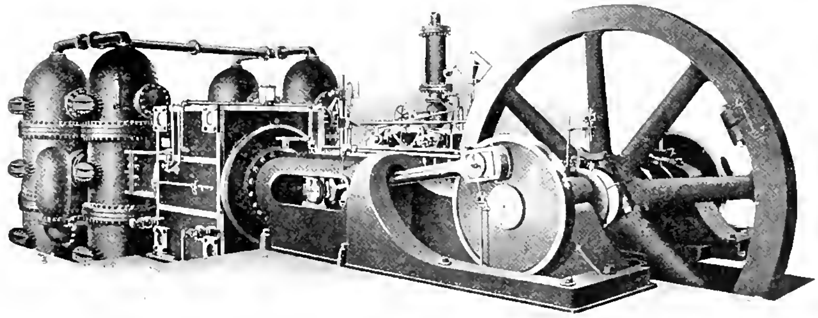
Horizontal Crank and Fly Wheel Pumping Engines

are particularly designed for hard service and long life and the valves are arranged in the annealed steel casting decks in such manner that the flow of water is not deflected in all directions, as is necessarily the case when the bee-hive or cage system is used.



Hamilton Corliss Engines are the most economical steam operated prime movers known and are sold on their operating record.

Send for Bulletin "F"

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Reducing the Pay-Roll—Improving the Product—Increasing the Capacity—

are the three most important accomplishments of a Conveyer System.

In these days of manufacturing retrenchment, architects and engineers are alive to the necessity of providing the best and simplest means for reducing time and labor in manufacturing processes. Development in gravity and power conveying devices have attracted wide and interested attention, and all promoters of industrial projects are giving the subject thorough investigation.

Be prepared to specify the best types of mechanical handling machinery by securing literature illustrating and describing the Mathews line of Standard Equipment—the oldest and best known in America.

GRAVITY ROLLER CONVEYERS
GRAVITY WHEEL CONVEYERS
AUTOMATIC ELEVATORS
GRAVITY ROLLER SPIRALS
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POWER PALLET CONVEYERS, Etc.

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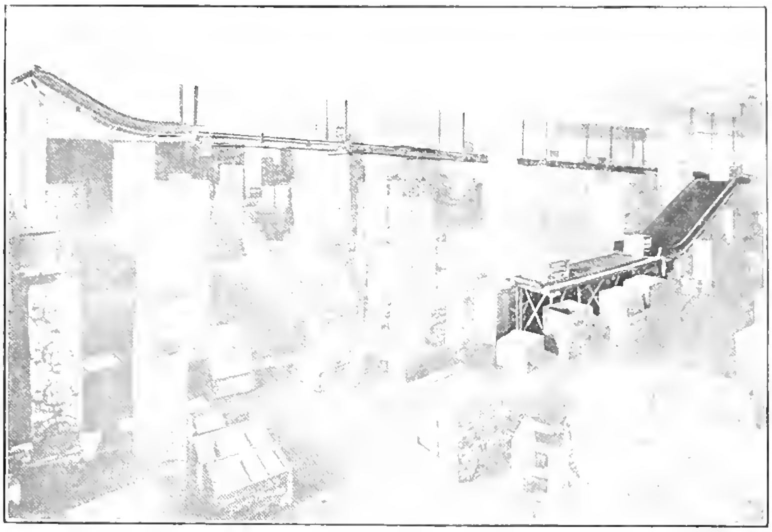
Cut out this coupon, attach it to your letter head and we will mail our full set of catalogs and bulletins illustrating and describing the Mathews line of Standard Equipment, consisting of Gravity Conveyers, Automatic Elevators, Gravity Roller Spirals, Gravity Spiral Chutes, etc. Sooner or later you will have use for the information given in our literature.



Mathews Gravity Roller Carriers and Steel Chutes in a Biscuit Factory

We have branch offices in all leading American cities with competent engineers in charge. Personal assistance given to architects and engineers in working out handling systems for their clients. We make no charge for this service.

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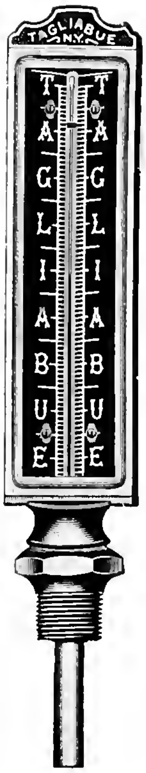

Do You Know Your Temperatures?

If temperature enters into your manufacturing processes, you should use

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Hohmann-type THERMOMETERS

They will always indicate your temperatures accurately; they are built to withstand the most severe strains; they are made to fit your special purpose. Made with any scale, of special stem materials, and with particular connections for particular applications.

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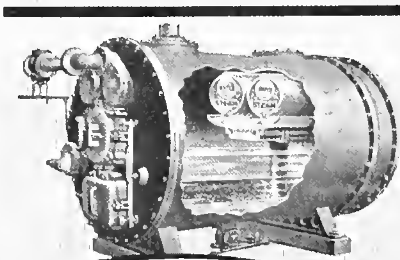

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Direct-Contact FEED WATER HEATER

has upward filtration. The filter material lasts longer—it cannot be carried to the pump.

Catalog No. 2

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***STANDARD* Equipments**

can be applied to all types and sizes of power Plants.

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Portable Electric Drills

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HAND AND BREAST DRILLS
HEAVY SERVICE DRILLS

Ventilated and Watertight

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HELICAL GEARS

are generated on the Gear Shaper on the same principle as spurs and internals. In either case a ground, generating cutter is used, which produces extremely accurate gears at low cost.

You are probably familiar with the spur machine. Write for circular descriptive of the Helical Gear Shaper.

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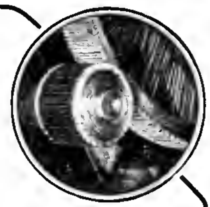
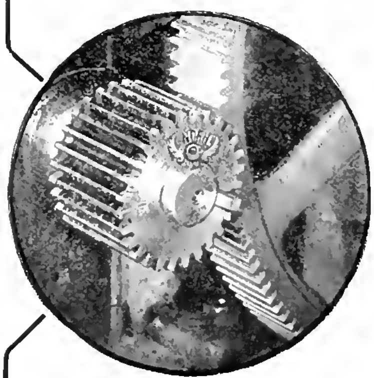
Springfield, Vt.

Yes, they LOOK about alike while they're running but they don't SOUND alike





The QUIET drive looks like this when it's not running. The pinion, you see, is New Process

Every high speed metal gear drive should include a New Process Pinion to do away with the metallic noises, to prevent destructive vibration and to prolong life of the intermeshing gear teeth.

Ask for our book "Noiseless Gear Driving" and if you want advice on gear problems, our engineers will help you without charge.

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NEW PROCESS GEAR CORPORATION
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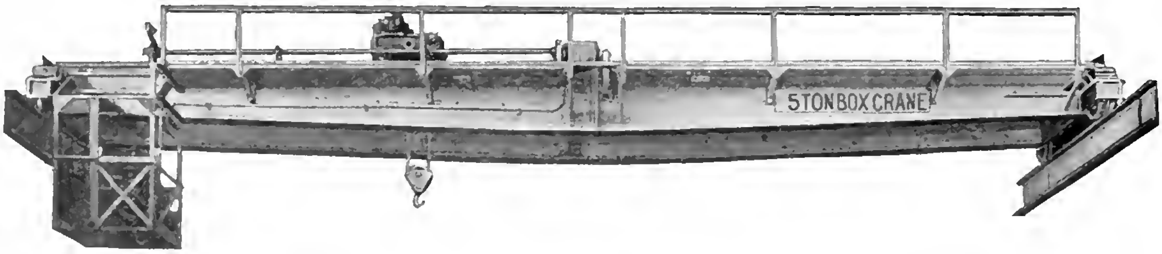
CANADIAN AGENTS: Robert Gardner & Son, Ltd., Montreal 85

ELECTRIC & HAND POWER CRANES, PORTABLE ELECTRIC & MONORAIL HOISTS



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GIVE RESULTS WHERE OTHER DRIVES FAIL

DESIGNED FOR HEAVY DUTY AND CONTINUOUS SERVICE
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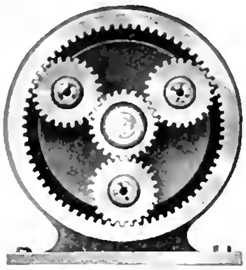

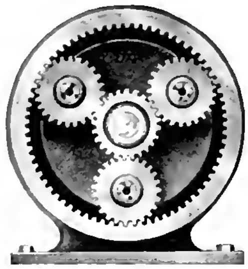

The above cut represents seven Model B Speed Reducing Outfits: ratio, 25.6:1; Direct connected to General Electric Motors, 5 H.P., 1140 R. P. M., giving a driven speed of 45 R. P. M. Motors and reducers are mounted on cast iron bedplates. The above outfits operate feed driers in a large cereal plant.

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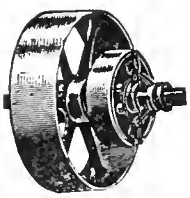

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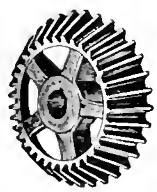

Gears of all kinds and sizes

SPECIAL MACHINERY

IRON CASTINGS

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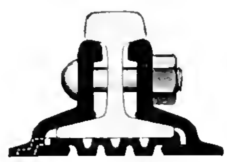
Continuous Rail Joint

Over 50,000 miles in use

Weber Rail Joint

Rolled from Best Quality Steel



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The Rail Joint Company

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Makers of Base-Supported Rail Joints for Standard and Special Rail Sections, also Girder, Step or Compromise, Frog and Switch, and Insulated Rail Joints, protected by Patents.

Highest Awards—Paris, 1900; Buffalo, 1901; St. Louis, 1904.

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are absolutely reliable instruments for the recording of output from machines.

In their design special attention has been given to making an instrument which will operate with the greatest ease. They are furnished with the following forms of driving mechanism: Revolution, Direct Drive and Rotary Ratchet.

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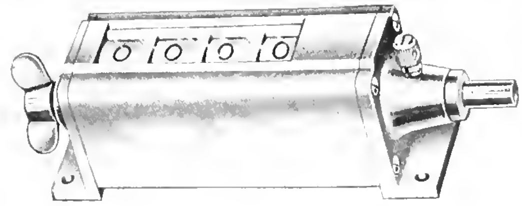
Makers of Cyclometers, Odometers, Tachometers, Tachodometers, Counters and Small Die Castings



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The "Setback Counter," illustrated above, is suitable for use in counting separate lots of work on Punch Presses, Printing Presses, Looms, Stamping Machines, Duplicators, Addressographs, Mimeographs, Coil Winders, Pumps, Engines, Screw Machines, Type Setting Machinery, or on any machines on which an accurate record of parts made is desired.

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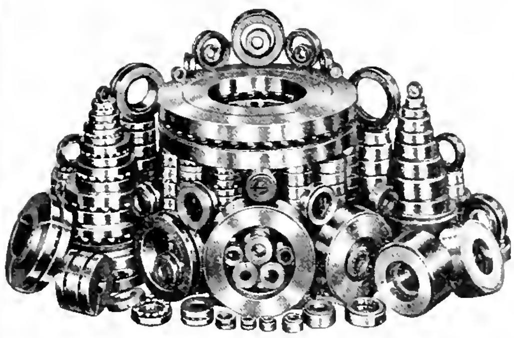
Reduce Wear and Tear, and Stop Lost Motion. Write today about your difficulties or send for Bulletin No. 12.

Washers, Races, Discs and Rings

of tool steel, hardened and ground, made to customer's specifications. Our excellent facilities insure high grade work. Send blue-prints of sizes today for quotation.



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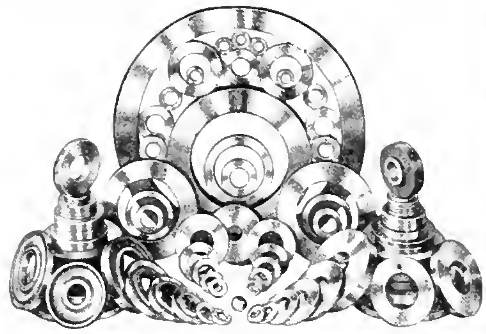

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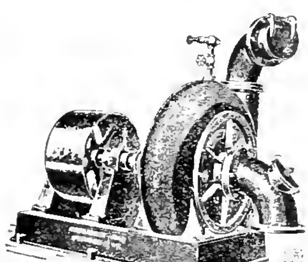

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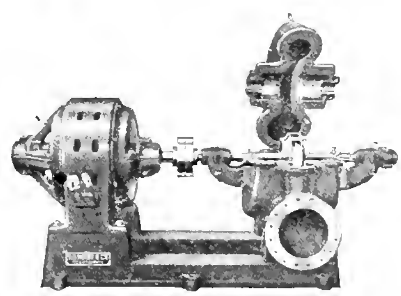
MANUFACTURERS OF C. I. Pipe, Gas Works Apparatus, Centrifugal Pumps, Hydraulic Tools of all description, Hydrants and Valves, Gas Producers.



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Makers of Alliance Cranes of all types; also Rolling Mill and Hydraulic Machinery, Steam Hammers, Punches and Shears, Scale Cars, Copper-Converting Machinery, etc.

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PHILADELPHIA, PA

Electric and Hand Power Cranes, Portable Electric and Monorail Hoists, Complete Track Systems.

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Elevating, Conveying and Power Transmitting Machinery. Helicoid and screw conveyors, machine molded gears, pulleys, fly-wheels, rope sheaves and drives, sprocket wheels and chain, buckets, belting, shafting and bearings.

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Elevators

Power Transmission

CLYDE IRON WORKS
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Hoisting Engines and Derricks. All sizes and types of engines.

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Manufacturers of Electric and Belt Power Passenger and Freight Elevators, Hoisting Machines, Friction Winding Drums, Friction Clutches and Friction Clutch Pulleys.

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Manufacturers of Goodrich Conveyor Belt. The Goodrich "Longlife" "Maxecon" and "Grainbelt" Conveyors will handle more tons per dollar of cost than any other belt made.

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Coal Handling and Hoisting Machinery, Conveyors, "Industrial" Railways, Automatic Railways, Electric Locomotives, Storage Battery Industrial Trucks, Electric and Steam Hoists, "Stevedore" Manila Rope.

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THE JEFFREY MFG. COMPANY
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Builders of Elevating, Conveying and Mining Machinery; Coal and Ashes Handling Systems for Power Plants; Screens, Crushers, Pulverizers, Car Hauls, Coal Tipples, Coal Washeries, Locomotives, Coal Cutters, Drills, etc. Complete Coal Mine Equipments.

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Hoisting Engines—steam and electric, for every use of the contractor, miner, warehouseman, railroads, shipowners, etc. Derricks, Derrick Irons and Derrick Hoists, Cableways for hoisting and conveying, Marine Transfer for coal and cargo handling.

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Elevators and Conveyors for every purpose; all accessories; Power Transmission Machinery. The Link-Belt Silent Chain Drive, Coal Tipples, Coal Washeries, Locomotive Cranes, etc.

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Conveyers

Automatic Elevators

MATHEWS GRAVITY CARRIER CO.

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Manufacturers of Gravity Carriers, Conveyers, Spirals, Chutes, and Automatic Elevators. Engineering Department at your service.

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Are the largest builders of Electric Traveling Cranes in the world. We also design and build Steel Plants complete, Hammers, Presses, Shears, Charging Machines and all kinds of Rolling Mill and Special Machinery.

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Manufacturers of Iron, Steel and Copper Wire Rope, and Wire of every description.

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Address 119 W. 40th St. New York, (*See Manning, Maxwell & Moore, Inc.*)

Electric Traveling Cranes for all purposes. Gantry Cranes. Wharf Cranes and Winches. Mono-Rail Systems.

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Special Machinery

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Contractors, Builders and Designers of Special Machinery.

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THE FELLOWS GEAR SHAPER CO.

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Manufacturers of Gear Cutting Machinery of the Most Advanced Type. In the Gear Shaper System a generating cutter is used which is ground after it has been hardened.

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Portable Electric Tools for Drilling, Reaming, Tapping, Grinding and Slotting.

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Builders of High Grade, Accurate, Special Machinery, Fixtures, Jigs and Tools.

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Air Compressors, twenty standard types, capacity 8 to 9000 cu. ft. per minute: "Little David," "Crown" and "Imperial" Air Hammers and Drills, all sizes; "Imperial" Air Motor Hoists, capacity ½ to 5 tons.

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Turret Lathes

JONES & LAMSON MACHINE CO.

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Manufacturers of the Hartness Flat Turret Lathe: made in two sizes for both bar and chuck work.

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Vertical Turret Machines, 28" and 34". Vertical Boring and Turning Machines, 42" to 84", inclusive.

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Papers on Air Compressors and Pneumatic Tools

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Vacuum Drying Apparatus (Passburg's Patents), High Efficiency Vacuum Pumps and Condensers. Drying experiments with various materials may be made at our experimental station.

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Gas Exhausters

Pumps

P. H. & F. M. ROOTS CO. CONNERSVILLE, IND.

Positive Pressure Blowers for foundries. High Pressure Blowers. Blowers for vacuum cleaning, for laundries, for blacksmiths. Positive Rotary Pumps. Positive Pressure Gas Exhausters. High Pressure Gas Pumps. Flexible Couplings.

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Dryers. Direct heat, Indirect heat, and Steam Dryers for all kinds of materials.

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Engines

B. F. STURTEVANT COMPANY HYDE PARK, MASS.

We make equipment to force or exhaust air under all conditions. Largest standard line of "ready to deliver" Fans in the world and special work done where necessary. Consulting representatives in or near your city.

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Aluminum Ingot, Sheet, Rod, Wire, Cable, Tubing and other forms.

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DOEHLER DIE-CASTING CO.

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Our methods and processes for producing Die-Castings are generally conceded to be the most reliable and efficient known. Send for our latest booklet "Successful Die Casting."

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Producers of Die-Cast Parts. Difficult parts completed when cast. No tooling. Engine bearings a specialty.

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Makers of Base-Supported Rail Joints for Standard and Special Rail Sections, also Girder, Step or Compromise, Frog and Switch, and Insulated Rail Joints, protected by patents.

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Radiators

THE H. B. SMITH CO.

WESTFIELD, MASS.

Sectional Cast Iron Water Tube and Return Flue Boilers. Also Direct and Indirect Radiators for Steam and Water Warming.

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Makers of Bright Cold Finished Bessemer, Open Hearth Crucible and Alloy Steels, in Rounds, Flats, Squares, Hexagons and Special Shapes.

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See page 329 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

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Papers Presented at Past Meetings of the Society

SHOP MANAGEMENT

No.	Title and Author	Price
449	Premium Plan of Paying for Labor, F. A. Halsey.	$ .20
647	Piece Rate System, Fred W. Taylor	.30
928	Bonus System of Rewarding Labor, H. L. Gantt.	.20
1001	Machine Shop Problem, C. Day	.20
1002	Graphical Daily Balance in Manufacture, H. L. Gantt	.20
1003	Shop Management, Fred W. Taylor (Paper)	.90
	(Cloth)	1 .50
1010	Slide Rules for the Machine Shop, C. G. Barth.	.20
1011	Modifying System of Management, H. L. Gantt	.10
1012	Is Anything the Matter with Piece Work, F. Richards	.20
1221	Training Workmen, H. L. Gantt.	.20
1326	Expense Burden: Its Nature and Incidents, S. Bunnell.	.20
1377	Axioms Concerning Manufacturing Costs, Henry R. Towne	.20
1378	Report of Sub-Committee on Administration of The American Society of Mechanical Engineers: The Present State of the Art of Industrial Management	.70

CONVEYORS

1403	Report of Committee on Hoisting and Conveying	$ .10
1235	Automatic Feeders for Handling Material in Bulk, C. K. Baldwin.	.10
1234	A Unique Belt Conveyor, E. C. Soper	.10
1222	Salt Manufacture (belt conveyors), Geo. B. Willcox	.20
1194	Belt Conveyors, E. J. Haddock.	.10
1193	Conveying Machinery in a Portland Cement Plant, C. J. Tomlinson.	.10
1192	The Belt Conveyor, C. K. Baldwin	.20
1191	Continuous Conveying Machinery, S. B. Peck	.20
1190	Hoisting and Conveying Machinery, G. E. Titcomb	.20
1195	Discussion on Papers 1194, 1193, 1192, 1191, 1190	.30
1404	Dynamic Braking for Coal and Ore Handling Machinery, C. T. Henderson	.10
1406	Cotton Conveying Systems, H. A. Burnham	.10

GEARS

1415	Gears for Machine Tool Drives, John Parker	$ .10
1382	The Strength of Gear Teeth, Guido H. Marx.	.50
1371	Investigation of Efficiency of Worm Gearing for Automobile Transmission, Wm. H. Kenerson	.20
1330	Herringbone Gears, P. C. Day.	.30
1292a	Tooth Gearing, J. D. Steven	.10
1292b	Interchangeable Involute Gearing, Wilfred Lewis	.10
1292d	Discussion on Papers 1292a and 1292b	.10
1219	Spur Gearing on Heavy Railway Motor Equipments, Norman Litchfield	.20
1218	Interchangeable Involute Gear Tooth Systems, R. E. Flanders	.30
	Majority Report of Committee on Standards for Involute Gears.	.10

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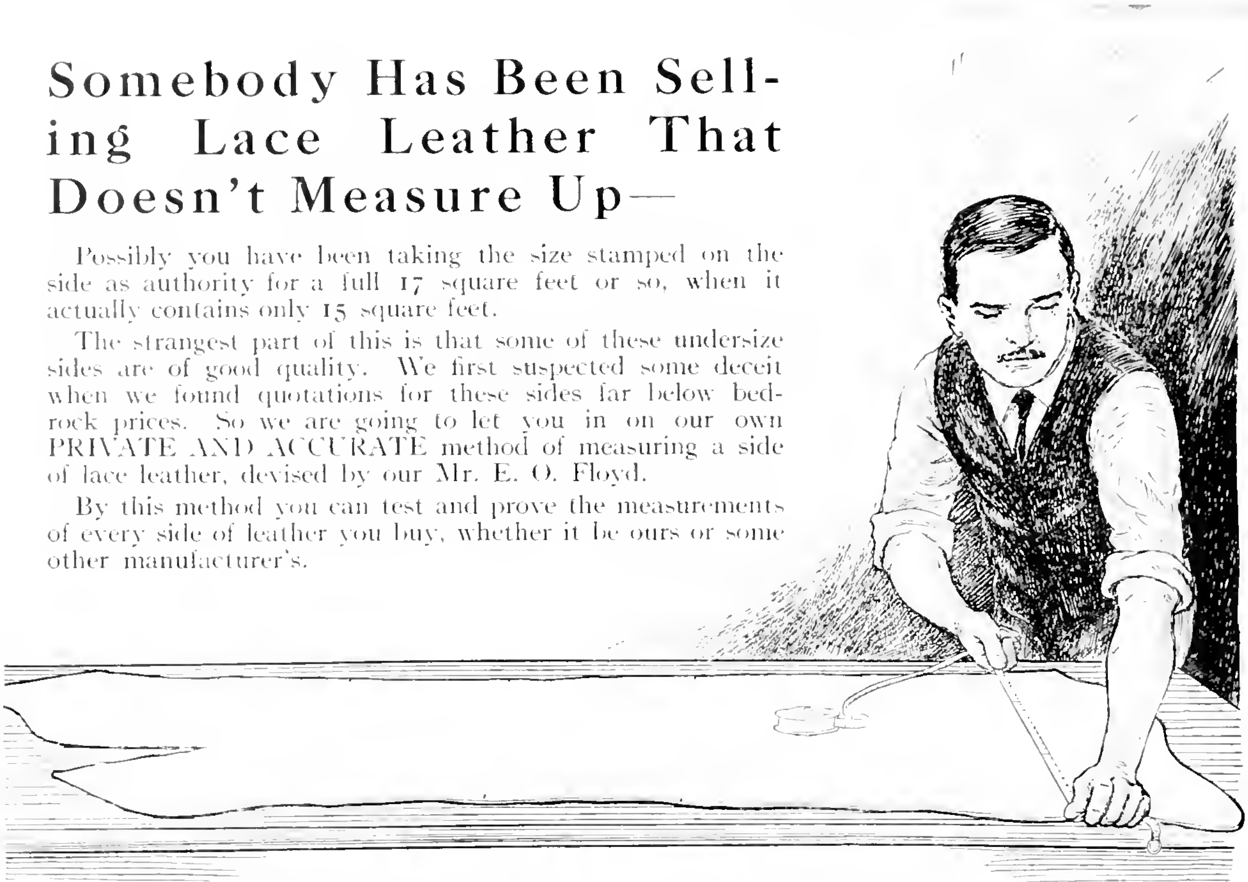
Possibly you have been taking the size stamped on the side as authority for a full 17 square feet or so, when it actually contains only 15 square feet.

The strangest part of this is that some of these undersize sides are of good quality. We first suspected some deceit when we found quotations for these sides far below bedrock prices. So we are going to let you in on our own PRIVATE AND ACCURATE method of measuring a side of lace leather, devised by our Mr. E. O. Floyd.

By this method you can test and prove the measurements of every side of leather you buy, whether it be ours or some other manufacturer's.

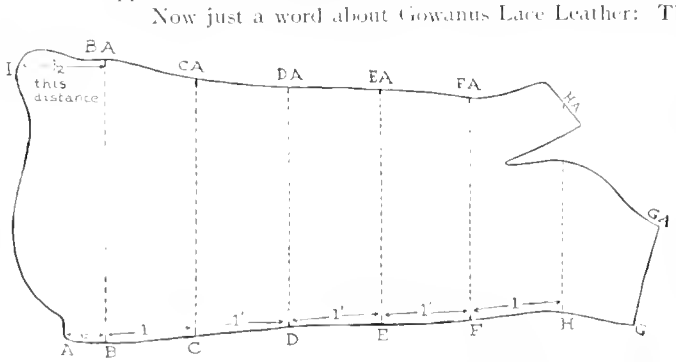


How to Measure Lace Leather

Take the diagram below and follow these instructions. Lay the side of leather flat on a table with the straight edge toward you. Measure from notch A 6 inches to point B, next measure off 1 foot from point B to C, and 1 foot from C to D, D to E and so on to the end of the side. Now go back to point B and find point BA, which must be square across (directly opposite) from point B. Measure from BA to I and take half of this measurement on the tape line (for example, BA to I is 1 foot and half this is 6 inches). In this instance start from the six inch mark on the tape line and measure across from point B to BA (for example, 3 feet); from the 3 foot 6 inch mark, on the tape, measure from C to CA, and continue to measure across the side from D to DA, E to EA, etc., carrying the measurement forward on the tape as you proceed. From point H to HA you will note there is a notch. Deduct the width of this notch. If point G is 1 foot from point H, simply measure from G to GA and the final figures on the tape line will be the exact square measurement of the side. But, if point G is less than 1 foot from point H, do not measure G to GA, instead measure from H to G and take one-quarter of this distance, which added to the previous figures will give you the square measurement of the side

The beauty of this method is that it requires no higher mathematics. Anyone can use it and its application to the sides you buy will insure full sizes, or a saving of from 60 cents to $1.00 a side.

Now just a word about Gowanus Lace Leather: This is a rawhide that is noted for its great strength, toughness and durability—and it is always full size. We don't raise the size a little to make up for a cut in price. But at double its price Gowanus would be worth more to you than ordinary lace leather, because it saves so much labor and time of idle machines while replacing broken laces.



If you haven't sold or used Gowanus Lace Leather it will pay you to write or wire us now for prices. We sell it in close trimmed sides and in strings cut to width. The latter are a full 100 feet to the bundle, too.

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Chas. A. Schieren Company

ESTABLISHED 1868.

GOWANUS, Rawhide
GIANT, Tanned
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ALPHABETICAL LIST OF ADVERTISERS

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

29 West 39th Street, New York

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

INCLUDING THE TRANSACTIONS OF THE SOCIETY

AUGUST · 1914

NEW MEMBERS AT THE ANNUAL MEETING

TO SECURE ADMISSION to the Society in time to participate at the Annual Meeting as a Member, applications should be filed not later than August 24. Applications received by that date will be posted in the September Journal, considered by the Membership Committee on October 10, and voted upon by the Council by letter-ballot closing November 15. Opportunity will be had therefore to qualify by the payment of initiation fee and dues prior to the Annual Meeting to be held December 1-4.

LISTINGS IN THE 1915 YEAR BOOK

All those who act in accordance with the foregoing paragraph, will be included in the List of Members for 1915, of which at least 20,000 copies will be distributed.

It will be possible also to include in the 1915 Year Book all those who file applications by September 23, provided they promptly comply with all requirements. Applications received at this later date, however, cannot be acted upon prior to the Annual Meeting.

The members of the Committee on Increase of Membership and of the Sub-Committees in the various cities listed below will be glad to assist in the preparation of applications or will supply more detailed information.

A brochure containing a description of new features and requirements for membership has been issued and may be had upon request.

COMMITTEE ON INCREASE OF MEMBERSHIP

I. E. Moultrop, *Chairman*

H. V. O. Coes	R. M. Dixon	E. B. Katte
F. H. Colvin	W. R. Dunn	R. B. Sheridan
J. V. V. Colwell	J. P. Ilsley	H. Struckmann

Chairmen of Sub-Committees

Atlanta, Park A. Dallis	*New York*, J. A. Kinkead
Boston, A. L. Williston	*Philadelphia*, T. C. McBride
Buffalo, W. H. Carrier	*Rochester*, J. C. Parker
Chicago, P. A. Poppenhusen	*St. Louis*, John Hunter
Cincinnati, J. T. Faig	*St. Paul*, Max Toltz
Cleveland, R. B. Sheridan	*San Francisco*, Thos. Morrin
Detroit, H. W. Alden	*Seattle*, R. M. Dyer
Los Angeles, O. J. Root	*Troy*, A. E. Cluett

Total Membership of the Society, July 20, 1914 .... *5837*
New Members since January 1, 1914 .... *544*

THE JOURNAL OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

Volume 36 AUGUST 1914 Number 8

CONTENTS

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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COMING MEETINGS OF THE SOCIETY

September 8, San Francisco, Cal. Subject: Hydroelectric Power Development in Conjunction with that of Domestic Water Supply.

November 18, New Haven, Conn. Fall meeting with afternoon and evening sessions, Mason Laboratory of Mechanical Engineering, Sheffield Scientific School, Yale University. Subject: The Generation and Application of Electricity in Manufacturing.

Annual Meeting, December 1–4, New York City. There will be a session on Engineering Metals, particularly Steels of Construction and for Tools; Cast Irons; and Alloys of Copper, Tin and Aluminum, etc.; and the entire day on Thursday, December 3, will be devoted to the general subject of the Engineer in Public Service, taking up problems in municipal engineering which are of interest to the mechanical engineer. The sub-committees on Railroads and Machine Shop Practice are arranging for sessions, and there will undoubtedly be groups of papers given under the direction of other committees, besides one session at which several important miscellaneous papers will be read.

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Volume 36 | August 1914 | Number 8

PUBLIC SERVICE AT THE ANNUAL MEETING

Some years ago the Constitution of the Society was amended to provide for a Committee on Public Relations, to have charge of those activities of the Society which include service to the public other than that rendered directly to the individual members and to the profession as a whole.

In furtherance of this idea the Public Relations Committee announces that Public Service has been designated by the Committee on Meetings as the central theme for the Annual Meeting in December 1914. At the request of the Committee, the Public Relations Committee has taken charge of the program for Thursday, December 3, and it will be devoted to papers on municipal engineering and related matters. The session will be opened by John Purroy Mitchel, Mayor of the City of New York, and the following papers, among others, will be presented during the day, according to a schedule to be arranged later:

Snow Removal, a Report of the Committee on Resolutions of the Snow Removal Conference held in Philadelphia, April 16-17, 1914.

Utilization of Municipal Wastes, by Irwin S. Osborne, designer and operator of the Columbus, O., Garbage Disposal Plant, and consulting engineer of the cities of Philadelphia, New York, Washington, D.C., and Toronto, Canada.

The Training of Municipal Employees, by H. M. Waite, City Manager, Dayton, O.

The Cleaning of Public Buildings, by Wm. H. Ball, Chief, Bureau of City Property, Philadelphia.

The Future of the Police Arm, by Henry Bruére, City Chamberlain, New York City, and Director of the National Bureau of Municipal Research.

Controlling Factors in Municipal Engineering, by Morris L. Cooke, Director, Dept. of Public Works, Philadelphia.

A Study of Cleaning Filter Sands, by Sanford E. Thompson, Consulting Engineer, Newton Highlands, Mass.

Municipal Colleges in Germany, by Clyde L. King, Instructor in Political Science, University of Pennsylvania, Philadelphia.

The Design and Operation of the Cleveland Municipal Electric Light Plant, Frederick W. Ballard, Commissioner of Lighting, Dept. of Public Utilities, Cleveland, Ohio.

This program only suggests the scope to be covered and further papers from our membership are requested.

The Society feels that it has a great opportunity in welcoming to its membership the growing body of engineers who are now engaged in putting the administrative work of our cities on an engineering basis. Branches of municipal work which but a few years ago were considered as having no engineering significance have assumed such proportions and are conducted along such lines as make imperative the employment of technically trained men. It is suggested by the Committee that this is an opportune time to present short memoranda, covering not more than two pages, outlining any recent changes in the conduct of different kinds of municipal work, which tend to put them upon an engineering basis and which may have come under the observation of our members.

IMPORTANT HEARING ON BOILER SPECIFICATIONS

Attention is called to the hearing to be held in the rooms of the Society on September 15 at 10 a.m., at which arguments and suggestions are to be presented upon the proposed report of the Committee to Formulate Standard Specifications for the Construction of Steam Boilers and other Pressure Vessels and for Care of Same in Service.

This report promises to be one of the most important ever issued by the Society. A large number of copies of a tentative draft of the report have already been sent to individual engineers, qualified to pass judgment upon it, and many helpful suggestions have been made. At the hearing in September, it is expected that accredited representatives of a number of organizations will appear, so that when the report finally comes up for discussion at the Annual Meeting, it will represent the concerted efforts of many able engineers and be in a form that will be generally acceptable to societies interested in steam boiler construction.

AN OPPORTUNITY FOR WORK[1]

It is only occasionally that we have an opportunity to discuss together what we as a Society are doing, and I am glad of the occasion to do so.

Membership in this Society should have as its purpose the opportunity for work rather than any personal benefit which may be derived, and we should all have an increasing sense of responsibility and privilege to render service.

All our committees, such as for instance the Boiler Specifications Committee, whose efforts have been the subject of discussion at this meeting, are doing zealous work, and such effort and loyalty to their profession is to be commended.

The committee whose work is continually being brought before you is the Publication Committee, and they, with the office staff, are endeavoring constantly to make our publication the best mechanical engineering paper in the field. This means, of course, a great deal of effort in editorial work and policy. I want to touch upon a point of controversy which has arisen through the attempt of the committee and the Council to direct the Society's efforts along what they consider the most intelligent line.

Only in America do technical societies publish two sets of publications, weekly or monthly or quarterly, and at the end of the year a bound volume in addition. Every German and every Frenchman and every Englishman saves his journals as a matter of course and has them bound up, if he wishes them, at the end of the year, and all but four or five societies in America do likewise. We are one of those four or five extravagant societies that present each member with a complete set of journals and at the end of the year a handsome bound volume in half morocco. The Council, after considerable thought on the matter, felt justified in wishing to divert the money spent in piling up such a set of books for the sentimental satisfaction involved, into what they considered more useful channels, but it has not worked out as the Council and Committee hoped. This evidently has not been properly put before the membership, as the Publication Committee and the Council are confident the membership would approve. Some of the other uses for the money now going into Transactions would be such work as the advancement of committee activities such as that of the Boiler Specifications Committee. The limited edition of the code which was issued for preliminary distribution cost $3000, and it must be obvious that this is only a beginning. A similar amount has been spent by the committee members themselves in their zeal to carry the work through. This is a customary thing in other societies, to have the members spend their own money in a public spirited way for the profession, but our own members are only beginning to realize that it is a privilege to spend their own money and their own time for the benefit of the profession. Mr. Stott, the chairman of the Flange Committee, has spent several years' time and great labor and expense in preparing charts to show a system by which flanges for high-pressure piping may be designed, and have some continuity of design. Because it is customary for the Society as such to pay for all the cost of committee work we are constantly pressed for funds.

We have seventy-five committees in the Society at work in different ways, and the Council and the Publication Committee have thought that the $15,000 which it costs for a duplicate set of publications might more wisely be spent in the development of the committee work.

We are also developing a library and a library service, so that those at a distance may derive benefit from the best technical library in the country. This is being done through searches, covering references to current articles upon any given subject, the charge for which is simply the actual cost of the labor involved in preparing the copy. This copy can be supplied either in the form of the magazines themselves, purchased by the library, or may be a typewritten transcription or a photographic reproduction of the articles.

During the coming Annual Meeting we are to have an entire session on the Relations of the Engineer to the Public, conducted by our Committee on Public Relations. Mr. Morris L. Cooke, director of public works at Philadelphia, has been instrumental in securing the most expert men available in the country to speak on subjects pertaining to engineering in the administration of a city.

This Society, with four others, has invited over 350 engineering societies of the world to come to America next year and unite with us in our celebration of the great engineering achievement, the completion of the Panama Canal, and over 175 of these have accepted. We were royally entertained in Germany last summer, not only by the Verein, but by Germany as a nation and by the various municipalities, as no society has ever been entertained before. Before that, in 1910, we were shown exceptional courtesies in England, and further back still, France was our host, so that we owe these foreign engineers the best we can give them. We have formed a joint reception committee, and Dr. Alex. C. Humphreys and Mr. Walter M. McFarland are respectively its general chairman and vice-chairman. This committee will need the coöperation of all our membership wherever they are situated in showing these engineers the hospitality of the various cities and extending to them the welcome of the profession. All these things mean participation in a large way in the affairs of the nation and the occupation of the place which we, as engineers, are striving to attain, namely, the position of national influence. I want to say that our Society is doing things all the time, and that

[1] Remarks made by Calvin W. Rice, Secretary, at the Spring Meeting, St. Paul, Minneapolis, 1914.

it is a good Society to be a member of. But I wish to emphasize that our position as engineers individually, as a Society, or as a profession, will be in direct proportion to the service which we render to the community in which we live, to the profession of which we are a Society, and to our great country of which we are citizens.

CALVIN W. RICE, *Secretary.*

A CALL FOR SPEAKERS

An invitation is extended to the members of the Society to volunteer their services to address the Student Branches during the coming season. Thirty-two of the leading colleges and technical schools of the country at present have associations which are affiliated with the Society and hold stated meetings under its jurisdiction. Most of the branches hold monthly meetings from October to May, and it is customary to have experts in various lines of engineering and industrial activity give talks or lectures at these meetings on some subject of current interest.

The Society undertakes to assist in the preparation of programs for each of its Student Branches and the rapid growth in the number of branches in the past few years makes it increasingly difficult to locate a sufficient number of speakers.

A generous response from the members to the invitation is anticipated, and it is requested that those who reply indicate the topics with which they are most familiar. Programs are already being formulated and a prompt response is therefore solicited. Members wishing to volunteer their services should communicate with the Secretary.

INTERNATIONAL ELECTRICAL CONGRESS

The purpose of the forthcoming International Electrical Congress in San Francisco in 1915 is twofold: the bringing together of a large and representative body of electrical engineers from all over the world, who shall find interest and inspiration in the Congress; and the erecting in its published transactions of a notable milestone of electrical engineering progress and development as a permanent record of contemporaneous electrochemical achievement. These published transactions will be available to members of the Congress at such a low price that either in part or as complete sets they will be within reach of all. Those who may be unable to attend the Congress may find a large measure of participation through possession of the transactions.

The meetings will be divided into twelve sections and there will probably be thirteen volumes in the complete set of its transactions, as follows:

(1) Generation, Transmission and Distribution
  Central station and substation design, control and operation. Long distance transmission of electric power.

(2) Apparatus Design
  Generators, motors and transformers. The rating of machinery.

(3) Electric Traction and Transportation
  City, surface and rapid transit railways; interurban and trunk lines; electric vehicles, ship propulsion, mining railways, elevators, and hoists.

(4) Electric Power for Industrial and Domestic Use
  Factories, mills, refrigeration, heating devices, etc.

(5) Lighting and Illumination
  Arc and incandescent lighting; the science and art of illumination.

(6) Protective Devices; Transients
  Switches, circuit breakers; condensers; electrostatics; disruptive phenomena; high-frequency phenomena.

(7) Electrochemistry and Electrometallurgy
  Electrolytic and metallurgical apparatus and processes.

(8) Telegraphy and Telephony
  (*a*) All communication of intelligence by the use of wires. (*b*) Electromagnetic waves and radiotelegraphy and telephony.

(9) Electrical Instruments and Electrical Measurements
  Switchboard, portable, standard and absolute instruments. Testing and standardization methods; absolute measurements.

(10) Central Station Economics
  Load factors, power factors, measurement of maximum demand and all problems affecting the economy of central stations; also rates, their regulation and legislation.

(11) Electrophysics
  Radioactivity; Röntgen rays; gas and vapor conduction; electron theory; constitution of matter, etc.

(12) Miscellaneous
  Such as history and literature of electrical engineering; symbols and nomenclature; engineering education and ethics.

(13) General Congress Proceedings

Communications may be addressed to

PRESTON S. MILLAR, Secretary-Treasurer
80th Street and East End Avenue
New York, N. Y.

PUBLICATION PLANS OF THE INSTITUTION OF MECHANICAL ENGINEERS

The Institution of Mechanical Engineers of Great Britain has taken an important step in the establishment of a monthly Journal, the first issue of which appeared in June. In size of page and typographical appearance it follows substantially the style of the pamphlet papers regularly issued by the Institution in advance of meetings.

The particularly interesting feature of this first number is an announcement of the new publication plans of the Institution. For many months the council has had under consideration methods of bringing into closer touch with the work of the organization those members who are resident in the country or abroad, and who are consequently unable to attend the meetings regularly. The outcome was the establishment of the Journal and an arrangement for binding that part of it which constitutes the Proceedings or Transactions; together with the advance printing of papers in pamphlet form, to be sent out upon request to members desiring them. In all particulars the plan is like that recommended also by the Publication Committee and Council of The American Society of Mechanical Engineers, and it is pleasing to note that the two societies, through the investigations of separate and independent committees, arrived at the same conclusions.

An examination of the present issue of the Journal shows that it is divided into two parts, each with an independent pagination. Part one contains information such as notices of coming meetings. In this particular instance, the program of the July-Paris meeting of the Institution, with abstracts of the papers to be presented, is given. By perusing these any member can judge whether or not a paper deals with matters in which he is interested or on which he desires to present a discussion, and if this should be so, a copy of the paper will be sent him.

Part two is of a different character and contains the full text of the papers presented at the previous meeting, together with the discussion so far as it can be completed up to the time of going to press. In the next issue following, the first place will be given to the completion of this discussion and the author's reply. This will be followed by the text of the next paper read, etc.

The Institution in various ways is enhancing the value of membership to those residing outside of London, and it is expected that arrangements will be made by which papers will be read simultaneously in other cities at the same time they are presented in London. Recent improvements in the house of the Institution will aid materially in this work. Through the acquisition of additional land, an enlargement of the building has been made. The main staircase has been widened and the ground floor now provides ample accommodations for the secretary and his staff in the new part of the building. On the mezzanine floor above these offices, a spacious committee room is to be found, and the council room is now located on the first floor, opening into one wing of the library. On the third floor a reading room and a smoking room for the members have been added. The design for the enlargement was made by Mr. James Millar of Glasgow, also the architect for the building of the Institution of Civil Engineers which faces that of the Mechanical Engineers on Princes Street, the frontages of the two buildings being rather similar in character.

OPENING OF THE NEW SOCIETY HOUSE OF THE VEREIN DEUTSCHER INGENIEURE

On June 5 the new society house of the Verein deutscher Ingenieure was opened with appropriate exercises, at which The American Society of Mechanical Engineers was represented by Frank B. Gilbreth, who was appointed Honorary Vice-President by the Council for this occasion. The new building is a magnificent structure, finished in the most substantial manner and utilized solely for the work of the Verein.

The proximity of the Imperial House of Representatives on the one hand, and the Brandenburg Gate on the other, imposed on the architects the difficult problem of designing a building in keeping with these two structures. This problem was solved in an admirable manner and the effect of large and impressive spaces is secured by connecting the windows of the first and second floors and maintaining the effect of vertical lines by suitable treatment of the walls, with crowns over the windows of the upper floors. Between the windows is a notable series in bas relief of the heads of famous German engineers, designed by Hugo Lederer.

FORMER HOME OF THE VEREIN DEUTSCHER INGENIEURE

On the ground floor is a spacious entrance hall and staircase, the main part of this floor, however, being unused at present and reserved for the future needs of the society. The feature of the building is the main meeting hall on the next floor, where are also several committee rooms. The main hall is decorated by a series of mural paintings, one of which is a view of Alexisbad in the Harz Mountains, where fifty-eight years ago twenty-three young engineers founded the

Verein. Another panel shows the Technical High School of Berlin and another the German Museum at Munich. At one end is an allegorical painting typifying engineering.

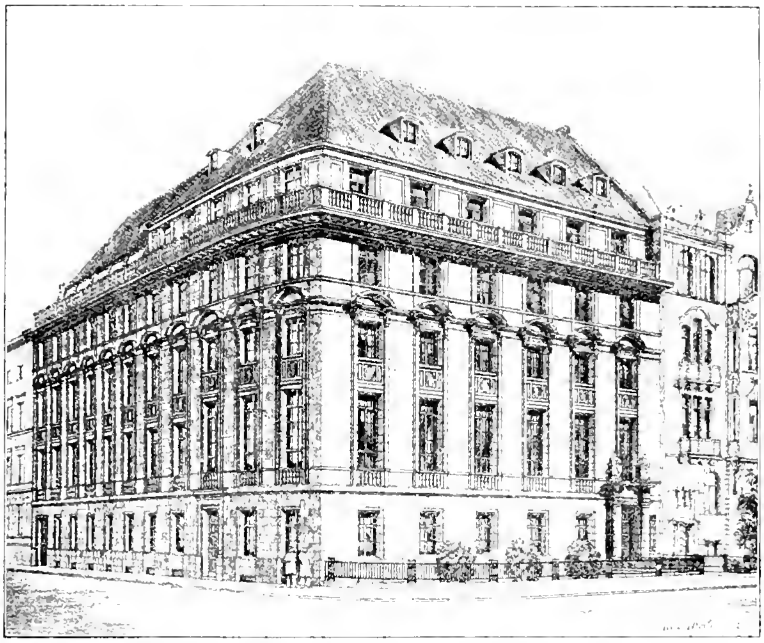
Two upper floors are devoted respectively to general offices for conducting the affairs of the Society, and the editorial and literary work and drafting connected with its publications, which form so important an element of the work of the Verein.

In a very high degree the Verein deutscher Ingenieure is what its name implies, the Society of German Engineers. While there are active and well patronized societies of electrical and mining engineers, practically every German engineer desires to become associated with the parent society. At the end of 1913 it had a membership of 24,500, more than a thousand times its charter list.

The influence of the Verein, as a bond between German engineers, extends far beyond the geographical confines of the German Empire. In addition to forty-eight local sections there are several recently created foreign branches, in Austria, England, China and in this country. These sections are practically autonomous. They have their own constitutions approved by the parent body, their own governing councils, may select honorary members, and receive a certain share of the dues paid in by their members. A local section may be formed, with the approval of the Verein council, by not less than 150 members of the organization.

The activities of the Verein extend considerably beyond the limits of mere reading of papers and discussions. Through its committees and funds, but above all through the hearty collaboration between its members and the organizations of which they direct the policies, the Verein exercises a potent influence on the development of technical education in Germany, and the standards of engineering research, especially such as is conducted in the laboratories of the splendidly equipped German Technical High Schools. Through its various committees the way is often paved for governmental regulations, and manufacturers are helped to adopt uniform practices in the classification of their output.

The publications of the Verein comprise the weekly Zeitschrift containing both papers presented before the various sections of the Society and contributions by members, as well as the usual editorial departments. The original articles are also available in separate reprints, the price of which is made especially accessible to members and students of engineering schools. As a supplement to the Zeitschrift is published a monthly, Technik und Wirtschaft, the purpose of which is to promote the knowledge of economic and social subjects among engineers. Another important publication is "Communications concerning Researches in the Field of Engineering," consisting of pamphlets appearing at irregular intervals, and presenting the results of researches conducted under the auspices of the Verein, mainly in the laboratories of technical schools. As a rule, extensive summaries of these researches appear in the Zeitschrift some time previous to the publication in complete form in the Communications.



THE NEW HOUSE OF THE VEREIN DEUTSCHER INGENIEURE

In addition the Verein publishes several series of books, such as Contributions to the History of Engineering and Industry and History of the Verein deutscher Ingenieure.

What is perhaps the most important result of the work of the Verein, however, is of such a nature that it can hardly appear in its official reports; and that is the change in the public opinion concerning the engineering profession in Germany in the last fifty years. For example, Werner von Siemens in his autobiography explains more than once that his social recognition was due to his status as a Prussian officer of artillery, rather than to his success as an engineer and inventor. That this situation prevails no longer and that engineers as such are recognized for their accomplishments and are leaders in public activity is due in large measure to the work of the Verein and the growing influence of its members.

DUTIES AND RESPONSIBILITIES OF THE ENGINEER[1]

By Henry L. Gantt

I wish to take this opportunity to lay before you in a few words, my idea regarding certain duties and responsibilities, which, if I read the signs of the times aright, will rapidly fall upon the shoulders of the engineer. In some quarters the engineer has already assumed these duties and responsibilities; in others, it has not yet been recognized that these duties belong to the engineer; but inasmuch as they are problems affecting our national welfare, and the engineer seems the only man fitted to solve them, there is no question that he will ultimately have to accept the responsibility for their solution.

It has been said that we are an industrial nation. I feel that we are only just beginning to be an industrial nation, and shall not be fully entitled to that name until we have a more complete knowledge of the principles on which successful industry is based. Too many of our enterprises are still founded on *what has been done* rather than on *what can be done*. The real industrial leader must be guided by future possibilities rather than past performances. The growing disposition among the people of all lands to abolish special privileges of every kind, is going to make it necessary for those who carry on industrial operations to depend more and more upon their own efficiency, and to get away as rapidly as possible from the errors of past practice. We can no longer blindly follow the trail of those who have gone before simply because they were successful. What spelled success yesterday, may spell failure tomorrow. Knowledge, not precedent or opinion, must be our guide. The man whose special training fits him to acquire the necessary knowledge is the engineer; he works with facts which he obtains by investigation; others are usually guided by opinion, which is too often inherited or copied.

Beginning as a designer of power plants, the mechanical engineer has become the most important factor in our development as an industrial nation. Content at first to design and install plants and equipment, he has realized that it was equally his function to operate them efficiently. This realization is the origin of the present widespread interest in the art of management, which is simply an attempt to apply to the subject of management the methods which the leading engineers have already so successfully applied to that of design. It is only natural that in the attempt to make such an application, the degree of success will, at first, largely depend upon the ability and training of the engineer undertaking the problem, but the day will come when the principles underlying the managing mechanism for an industry *will be as clearly defined and as well understood as those underlying the design of a steam engine, or an electric generator.* It is the function of the engineer to discover or develop these principles. This is not an easy job, for the human factor is the prime one to be considered, and many well-intentioned people have not yet learned that the man in overalls does not differ essentially from the man in the silk shirt.

During our visit to Germany last summer the high estimation in which the engineer was held in that country was evident on all sides. There, he is looked up to for the solution of all their industrial problems, and is no doubt largely responsible for the rapid industrial progress of that nation. Recognizing the importance of the educated engineer, and realizing that unless he had equal rank with other professional men, he would not have the influence that he should have, the Germans invented the degree of Doctor of Engineering, and bestowed it liberally, with the result that the new profession soon took rank with the older professions in the estimation of the people, and we found many of the highest civic positions held by the leading engineers. What could be more appropriate in an industrial nation?

The greatest industrial problem before us as a nation today is the relation between employer and employée. Congress has recognized this fact by appointing a commission to study the subject, and to recommend legislation. This commission, before whom I had the honor of testifying not long ago, is composed of very intelligent and capable men, and one woman whose insight and sympathies are very keen. On this commission the manufacturer, the lawyer, the economist, the philanthropist and the labor leader are to be found, but there is no engineer. Can we have any better evidence that the people at large have not yet discovered the engineer, or that they do not know what his function is?

How are we to bring to the attention of our legislators the fact that there are people in the community whose business it is to investigate and find the solution of industrial problems? Should our local sections not make education on this point one of their duties?

The present unsatisfactory industrial situation is due largely to the fact that most attempts to solve these problems have been made by the financier and the workman, both of whom have attempted to find a solution which would give his class the advantage. Financiers on the one hand, and unionists on the other are thus continually on the verge of a conflict.

What is the solution? Somebody must come between these two and study the subject from an impartial standpoint, and with the object of doing justice to each. The man whose training best fits him for this work is the engineer, and in many cases where he has attacked the problem the results have been most encouraging. With increasing knowledge and experience he promises to make rapid progress in the near future.

If engineers as a class and people in general can be brought to recognize that the engineer is the man best

[1] Address at the opening session of the Spring Meeting, St. Paul, Minn., June 1914.

fitted for solving the problems he has had such a large part in creating, we may hope in a few years to see marked progress toward industrial peace.

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i.e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by advising the Secretary promptly of anyone whose eligibility for membership is in any way questioned. Members will be furnished with complete records of any candidate thus questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before September 10, 1914.

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Adams, Conrad R., Wks. Engr., F. I. A. T. Co., Poughkeepsie, N. Y.
Almert, Harold, Cons. Engr., The Rookery, Chicago, Ill.
Anderson, Emil C., Mech. Engr., Colorado & Southern Rwy., Denver, Colo.
Bassett, George B., Pres. and Genl. Mgr., Buffalo Meter Co., Buffalo, N. Y.
Bockius, Charles A., Asst. Mech. Engr., Fuel Testing Co., Boston, Mass.
Bourne, Ralph H., with Whiting Foundry Equipment Co., Harvey, Ill.
Burnet, Tom, Engr.-in-charge, Bulawayo Water Works Co., Ltd., Bulawayo, So. Africa
Burpee, Frank E., Prof. of Mech. Engrg., Bucknell Univ., Lewisburg, Pa.
Carter, Harry D., Mech. Engr., Samuel M. Green Co., Springfield, Mass.
Cilley, Raymond, Designing Engr., Troy Wagon Works Co., Troy, Ohio
Clarke, Edgar W., Ch. Engr., Cambria Steel Co., Johnstown, Pa.
Cleghorn, Mark P., Assoc. Prof. Mech. Engrg., Iowa State College, Ames, Ia.
Coffman, Joseph P., Supt. Dept. Mchy., National Transit Co., Oil City, Pa.
Conran, Fred M., Supt., The Torrington Mfg. Co., Torrington, Conn.
Cramer, Virgil P., Experimental Engr., The Garford Co., Elyria, Ohio
Crane, J. B., Commercial Engr., Great Northern Power Co., Duluth, Minn.
Cutler, Frank G., Chief, Bureau of Steam Engrg., Tennessee Coal, Iron & R. R. Co., Ensley, Ala.
Davis, Fred R., Ch. Engr., Pwr. Plant, Pittsburgh Plate Glass Co., Kokomo, Ind.
Dean, Henry L., Mech. Engr., Compressor Dept., Chicago Pneumatic Tool Co., New York
Dodge, Frederick H., Pres., The Ohio Electric Car Co., Toledo, Ohio
Dougherty, John H., Mech. Engr., Lehigh & Wilkes-Barre Coal Co., Wilkes-Barre, Pa.
Dunham, Walter E., Supvr., Motive Pwr. and Mchy., Chicago & North Western Rwy., Winona, Minn.
Ehrman, Edwin H., Secy. and Factory Mgr., Chicago Screw Co., Chicago, Ill.
Elsas, Oscar, Pres., Fulton Bag & Cotton Mills, Atlanta, Ga.
Fales, George L., Supt. Pwr. Dept., Tennessee Copper Co., Copperhill, Tenn.
Finkle, Frederick C., Cons. Engr. in Mech. and Hyd. Work, Los Angeles, Cal.
Fogarty, Michael J., Mgr. and Prop., Machine Shop, Brooklyn, N. Y.
Frauenfelder, Joseph B., Ch. Engr., Lake Torpedo Boat Co., Bridgeport, Conn.
Gentzel, Perry H., with The Cincinnati, Bluffton & Chicago R. R., Huntington, Ind.
Gilson, Henry R., Ch. Engr., National Metal Molding Co., Pittsburgh, Pa.
Glenn, John F., Contr. Engr., The Wickes Boiler Co., Buffalo, N. Y.
Gordon, Leo A., Supvr. Engrg. Dept., City of Fall River, Mass.
Gurney, Howard F., Pres. and Genl. Mgr., Gurney Elev. Co., New York.
Hall, Walter H., Mech. Supt., Chelsea Fibre Mills, Brooklyn, N. Y.
Hamilton, John W., Senior Member, Hamilton & Chambers, New York
Hansen, Anton, Ch. Draftsman, The Kelly & Jones Co., Greensburg, Pa.
Harter, Clarence J., Ch. Draftsman, Remington Arms-U. M. C. Co., Bridgeport, Conn.
Hartford, John A., Secy. and Genl. Mgr., Breese Motor Plow Co., Wapakoneta, Ohio
Haynes, Charles A. R., Asst. Engr., The New York Steam Co., New York
Jewell, George H., with Lytton Mfg. Corp., Franklin, Va.
Keating, Thomas E., Engr., Turbine Engrg. Dept., The Westinghouse Mch. Co., East Pittsburgh, Pa.
King, William R., Cons. Engr., with S. F. Tainter, New York
Kötter, George, Superintending Engr., Hamburg-American Line, New York
Laine, William B., Engr., American Tobacco Co., New York
Lathrop, Daniel W., Vice-Pres., Atlas Crucible Steel Co., Dunkirk, N. Y.
Lawton, Ralph W., Mgr., Jewell Export Filter Co., Calcutta, India
Loewy, George J., Principal, Murray Hill Vocational School, New York
Lowell, Floyd C., with Prentiss Tool & Supply Co., Buffalo, N. Y.
McGahey, Calvert R., Mech. and Elec. Engr., Baltimore, Md.
MacKlind, William R., Mgr. Engrg. and Constr. Dept., The Sherwin-Williams Co., Cleveland, Ohio
Mills, Charles, Foreman Pattern Shop, California Iron Works, Riverside, Cal.
Muncy, Victor E., Prof. of Mechs. and Applied Elec., Ohio Mechanics Inst., Cincinnati, Ohio
Nickelsen, Theodore, Cons. Sugar Engr., Manila, P. I.
Ormond, John C., Ch. Material Agt., Messrs. Vickers Ltd., Harrow, England
Pennock, Richard M., Mech. Engr., Pennsylvania Dept. of Labor & Indus., Harrisburg, Pa.
Roberts, Arthur L., Mech. Engr., Lehigh Valley R. R., South Bethlehem, Pa.
Roger, John P., Plant Engr., Babcock & Wilcox Co., Barberton, Ohio
Runyan, Frank K., Supvr. of Production, The Dayton Engrg. Laboratories Co., Dayton, Ohio
Schmalz, Charles H., Asst. Master Mech., Anaconda Copper Mining Co., Great Falls, Mont.

Sc[illegible]er, Gelhart A., Works Engr., Standard Steel Car Co., Hammond, Ind.
Schreiber, Carl T., Publicity Engr., Hill Publishing Co., New York
Schreiber, John W., Mech. Engr., Aluminum Company of America, Pittsburgh, Pa.
Scrugham, James G., Prof. of Mech. Engrg., University of Nevada, Reno, Nev.
Sheehy, John P., Foreman, The O. M. Edward Co., Inc., Syracuse, N. Y.
Shepard, George R., Mech. Engr., Hydraulic Power Co., Niagara Falls, N. Y.
Stevens, Austin P., Master Mech. and Ch. Engr., Cochrane Chemical Co., Everett, Mass.
Stimson, Morris H., Plant Mgr. Dunkirk, N. Y., Plant, United States Radiator Corp., Dunkirk, N. Y.
Stoll, Clarence G., Supt., Bell Telephone Mfg. Co., Antwerp, Belgium
Sykes, Walter J., Head of Mech. Dept., Div. of Works, Panama Pacific Internatl. Exposition, San Francisco, Cal.
Thorn, George W., Armour Institute of Technology, Chicago, Ill.
Upington, George P., Sales and Combustion Engr., Blaisdell-Canady Co., New York
von Vittinghoff, Hans, Secy. to Vice-Pres., Stone & Webster, Boston, Mass.
Wiebe, Sigard J., Cons. Engr., Brooklyn, N. Y.
Williams, William E., Local Engr., American Car & Foundry Co., Berwick, Pa.
Wohlers, Charles, Designing Engr., Electric Bond & Share Co., New York
Worker, Joseph G., Engr. Stoker Dept., Westinghouse Machine Co., Chicago, Ill.
Wright, Howard G., Ch. Draftsman, Washoe Reduction Works, Anaconda Copper Mining Co., Anaconda, Mont.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Avery, Harold T., Ch. Draftsman, Ames Iron Works, Oswego, N. Y.
Bachman, Benjamin B., Engr., The Autocar Co., Ardmore, Pa.
Brunner, Hans, Mech. Engr., Essex Rubber Co., Inc., Trenton, N. J.
Bryan, Walter E., Supt., Pwr. Stations, United Railways Co., St. Louis, Mo.
Cahill, Edward H., Engr., Mottlau Transmission Co., Philadelphia, Pa.
Carson, Charles B., Mech. and Constr. Engr., Taylor Instrument Cos., Rochester N. Y.
Clark, William F., Heating and Ventilating Engr., State Architects Office, Albany, N. Y.
Engblom, Alexander, Mech. Engr., Sidney Blumenthal & Co., Shelton, Conn.
French, James C., Ch. Engr., F. C. Austin Drainage Excavator Co., Winthrop Harbor, Ill.
Gallaher, Alvan H., Asst. Engr., Barrett Mfg. Co., New York
Gilbert, Huntly H., with Pressed Steel Car Co., Chicago, Ill.
Jefferson, Carl J., Asst. Supt. Mfg., American Ice Co., Philadelphia, Pa.
Lindemuth, Francis L., Squad Foreman, Drawing Room, Cambria Steel Co., Johnstown, Pa.
McPherson, Charles J., Asst. Ch. Draftsman, J. G. Brill Co., Philadelphia, Pa.
Moore, William J., Designing Engr., Niles-Bement-Pond Co., Plainfield, N. J.
Naylor, Charles L., Mech. Engr., E. F. Houghton & Co., Philadelphia, Pa.
Rennie, Walter M., Asst. Res. Engr., Gardner S. Williams, Ann Arbor, Mich.
Scofield, Gilbert J., Mech. Engr., Hilliard Clutch & Mchy. Co., Elmira, N. Y.
Swanson, Herman O., with Jamestown Table Co., Jamestown, N. Y.
Szu, Ping Nyoen H., Engr., Linke Hofmann Werke, Breslau, Germany
Thomas, Raymond H., Mch. Designer, Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Wait, William B., Asst. Engr., Spreckels Sugar Refining Co., Philadelphia, Pa.
Young, Emanuel J., Foreman of Elec. Repair Shops, Cambria Steel Co., Johnstown, Pa.

FOR CONSIDERATION AS JUNIOR

Bechert, Fred J., Instr. in Mech. Engrg., Texas Agri. & Mech. College, College Station, Texas
Besse, Eldred E., Mech. Engr., Lowell Gas Light Co., Lowell, Mass.
Bolte, Edward E., Draftsman, Waugh Draft Gear Co., Chicago, Ill.
Clapp, Richard B., Load Dispatching Engr., Penn. Water & Power Co., Baltimore, Md.
Cook, Henry P., Draftsman, Babcock & Wilcox Co., Bayonne, N. J.
Drew, William N., Chem. Engr., Western Precipitation Co., Los Angeles, Cal.
Hall, Leigh S., with Hall Brothers Supply Co., Concord, N. H.
Heinemann, Adelbert L., Inspr. Test Dept., Pennsylvania R. R., Altoona, Penn.
Hilyard, LeRoy, with International Steam Pump Co., Philadelphia, Pa.
Hosmer, Fred E., Asst. Mech. Engr. and Draftsman, Gulf Pipe Line Co., Beaumont, Tex.
Karcher, Harry E., Retort Foreman, American Creosoting Co., Indianapolis, Ind.
McLaren, George C., Mech Engr., Whittier Water Co., Whittier, Cal.
Mansfield, Clifford B., Draftsman and Civ. Engr., The Palmetto Phosphate Co., Tiger Bay, Fla.
Milligan, Vincent B., Locomotive Inspr., Louisville & Nashville R. R. Shops, Lexington, Ky.
Pennell, S. Howard, Foreman and Inspr., Meter Dept., Yarnall-Waring Co., Philadelphia, Pa.
Phillips, Leon R., Mech. Asst., Constr. Dept., Swift & Co., Boston, Mass.
Sanders, Walter C., Mech. Engr., Cedartown Foundry & Machine Works, Cedartown, Ga.
Smith, Howard S., Material Inspr., Atchison, Topeka & Santa Fé R.R., Topeka, Kan.
Strale, Nels W., Coke Plant Operator, H. Koppers Coke Co., Chicago, Ill.
Taylor, John E., Spec. Apprentice, New York Central & Hudson River R.R., New York
Thomas, Felix, Asst. Pat. Atty., National Cash Register Co., Dayton, Ohio
Thornhill, Theodore W., Mgr., Charleston Oil Co., Charleston, S. C.
Zeigler, Kenneth G., Specl. Apprentice, New York Central & Hudson River R. R., Avis, Pa.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM JUNIOR

Brown, Dickson Q., 2nd Vice-Pres., Tide Water Oil Co., New York
Heaton, Herman C., Mech. Engr., Sargent & Lundy, Chicago, Ill.
Hunt, Eugene A., Mech. Engr., Los Angeles, Cal
Thomas, George C., Supt., Singer Company, Podolsk, Russia
Weber, Erwin L. F., Cons. Domestic Engr., Seattle, Wash.
Williams, Nezza N., Junior Partner, E. T. Archer & Co., Kansas City, Mo.

SUMMARY

New applications	123
Applications for change of grading	
Promotion from Junior	6
Total	129

THE SPRING MEETING

THE Spring Meeting at St. Paul-Minneapolis, the first meeting of the Society to be held in the "Twin Cities," was a decided success. The attendance was unexpectedly large, influenced probably as much by the natural local attractions as by the program of professional papers. The Local Committee, consisting of Max Toltz, Chairman, Chas. L. Pillsbury, Vice-Chairman, E. J. Heinen, Secretary, Paul Doty and W. H. Kavanaugh, had made extensive provision for the comfort and entertainment of the visitors, and the numerous social features, with the various excursions to plants of interest in the vicinity, were thoroughly enjoyed.

The meetings were held from June 16 to 19, with headquarters at the St. Paul Hotel in St. Paul, there being 121 members registered and 279 guests, a total of 400. The professional meetings were held in the ball room of the hotel, with the exception of the Thursday forenoon session, which was held in the Engineering Building of the University of Minnesota in Minneapolis. The usual Friday morning session was replaced by technical excursions which, in line with the present practice of the Committee on Meetings to provide increased opportunity for social attractions at the Spring Meeting, did much to add to the pleasure of the meeting. Interest in the meeting was also enhanced by the provision by the local committee of several papers of local interest.

The headquarters were opened in the hotel for the registration of members at noon on Tuesday. At four o'clock, the elaborately equipped special train arrived from Chicago over the Chicago, Burlington & Quincy Railroad, and was met at the Union Depot by special street cars that conveyed the party to the headquarters. About 115 members and guests came on this train and reported an enjoyable trip. Several stops were made en route to view features of interest.

TUESDAY EVENING RECEPTION

At 8:30 in the evening a reception was held, followed by addresses by the Chairman of the local committee, by Governor A. O. Eberhardt, representatives of the city of St. Paul, including the Mayor, and by H. L. Gantt, vice-president of the Society, who, in the absence of the President, James Hartness, replied for the visitors. Mr. Gantt spoke of certain duties and responsibilities which will undoubtedly fall upon the shoulders of engineers. In some quarters the engineer has already assumed these responsibilities, in others, it has not yet been recognized that such duties belong to the engineer; but inasmuch as they are problems affecting our national welfare and the engineer seems to be the man best fitted to solve them, there is no question but that he will ultimately have to accept the task of their solution.

BUSINESS SESSION

The business session of the Spring Meeting was called to order on Wednesday morning by Vice-President Gantt. As the first order of business, the Secretary announced the membership ballot upon the amendments to the Constitution, proposed a year ago, with respect to the grades of Member and Associate-Member. These amendments were approved and in each case resulted in raising the requirement for membership. Under the new plan one must have reached thirty-two years of age to become a member, and must have been in active practice of his profession for at least ten years and in responsible charge of important work for five years; or if a teacher, equivalent experience is required as professor of engineering in charge of a department. To become an Associate-Member, a candidate must be at least twenty-seven years of age with six years' professional experience and one year in responsible charge of work. With these amendments the Society now ranks with those having the very highest professional requirements.

The Secretary further announced the vote of the tellers on the Code of Ethics published in The Journal for January 1913, by which this was declared to be the code of the Society.

Henry Hess moved that article C 45 of the Constitution be amended by adding to the list of standing committees the Committee on Standardization. This will come up for discussion at the Annual Meeting.

The next subject was the report of the Committee on Standardization of Flanges. This report had previously been approved by the Council with an expression of high appreciation of the work which had been done. The report as presented was the result of conferences of several bodies interested, held at Washington, D. C., in March and in the rooms of the Society in New York in April. At these conferences several changes were made in the schedule as presented for preliminary discussion at the Annual Meeting in December and published in The Journal for January under the title of the "American Standard." The various differences of the several interests had been adjusted satisfactorily with the one exception of the name by which the report should be known. Earnest T. Child and Edward B. Denny spoke for the National Association of Master Steam and Hot Water Fitters in favor of the name "1915 U. S. Standard." As the first report was issued under the name "1912 U. S. Standard" and had become widely known, they felt that it would be advantageous to retain the name, with the date changed. As their organization had initiated the movement for standardization, the continuation of the original name would also be in the nature of a courtesy to them. A. B. Carhart said that orders were

coming to his firm for "U. S. Standard" flanges as a result of the 1912 report, without distinction being made as to the year, and that confusion might arise if the revised report should bear a similar title.

A motion was made and carried that the matter of the name be referred to a committee composed of appointees of each of the societies or bodies interested in this report.

Next followed what proved to be the event of the business meeting, a discussion upon the subject of specifications for steam boilers. The tentative draft of the Committee on Steam Boiler Specifications had been printed and distributed among a large number of engineers so that the work of the committee might be checked up and revised before the report was submitted for general discussion as will be the case at the next Annual Meeting. There had been a meeting at Chicago on the previous Monday attended by representatives of the Association of Steel Manufacturers, the Association of Tubular Boiler Manufacturers and the Boiler Specifications Committee of the Society at which there was discussion with regard to the steel specifications to be embodied in the report. The discussion on Wednesday morning was mainly a continuation of that started at Chicago and the Chairman announced that it would be considered informal only. It led to a motion providing for a meeting at which the organizations, manufacturers and others concerned could appear to present their arguments before the Committee and during the discussion of this the Chairman finally asked those most interested to adjourn to another room so that the resolution could be put into a definite shape and be presented to the meeting at the following session. This was done and at the afternoon session, E. E. Keller, Vice-President, who acted as Chairman at the separate meeting, read the following resolutions:

Resolved that on September 15, 1914, a committee hold in the rooms of The American Society of Mechanical Engineers, 29 West 39th Street, New York, a hearing of all interested and concerned in the preliminary report of the committee appointed to formulate standard specifications for the construction of steam boilers and other pressure vessels and for care of same in service, and that those desiring to participate in the discussion present in writing their criticisms and discussions prior to August 15.

Resolved that in addition to invitations, notification by publication in the technical press be given to the hearing.

The resolutions were adopted after considerable discussion.

PROFESSIONAL SESSIONS

Following the business meeting, the first technical session was held on the subject of Powdered Fuel, which was followed by a topical discussion with several contributions in reply to a set of questions covering a number of items relating to the use of pulverized coal.

Two other technical sessions were held during the meeting, one on Wednesday afternoon, with a series of miscellaneous papers, and one on Thursday morning at the University of Minnesota, when papers by local engineers were presented. These will be reported in The Journal. The following is a list of the papers read:

Pulverized Coal Burning in the Cement Industry, R. C. Carpenter
Pulverized Coal for Steam Making, F. R. Low
An Installation for Powdered Coal Fuel in Industrial Furnaces, Wm. Dalton and W. S. Quigley
Industrial Service Work in Engineering Schools, J. W. Roe
Classification and Heating Value of American Coals, Wm. Kent
The Railroad Track Scale, W. Wallace Boyd
Gear Testing Machine, Wilfred Lewis
A Flow Metering Appliance, A. M. Levin
Power Development at the High Dam Between Minneapolis and St. Paul, Adolph F. Meyer
The Handling of Coal at the Head of the Great Lakes, G. H. Hutchinson
Minneapolis Flour Milling, Charles A. Lang

CONFERENCE LUNCHEON

Following the adjournment of the Wednesday morning session, June 17, a conference luncheon was tendered by the members of the Council to representatives of local committees and sections in attendance at the meeting. The Council was represented by Messrs. Gantt, Reist, Keller, Davidson, Jackson, Hess, Hunter, and Secretary Rice, and 13 representatives of the Minnesota section and other local committees, the luncheon being laid for 21 covers.

Opportunity was here offered for a general discussion of local committee and section matters, and Secretary Rice pointed out the great opportunity for development of the activities of the Society through the local section work, giving an account of the present state of this branch of the Society's affairs. He also gave an interesting account of publication matters and other features of general interest in connection with the work at the headquarters in New York.

WEDNESDAY EVENING LECTURE

On Wednesday evening John Hearding, superintendent of the Oliver Iron Mining Company, Duluth, delivered a lecture on Ore Handling, in which he showed all phases of iron mining work on the Mesaba Range from the rough mining methods in the pit to the shipping of the ore and its chemical analysis. The speaker illustrated his remarks with moving pictures which showed the processes in the most graphic manner, including the steam shovels at work, the various methods of mining, especially the open method which is the one employed with the steam shovel, and finally the shipment of the ore itself. Sampling of the ore was shown and also the weighing of each car automatically as the train passes. The rapidity with which a vessel may be loaded with the ore from the stock bins into which it is delivered from the train was also shown.

There was a large attendance at this lecture, which was one of the most successful events of the convention.

SESSION AT THE UNIVERSITY OF MINNESOTA

The meeting of Thursday morning was held in the main engineering building of the University of Minnesota, in Minneapolis, and was called to order at 10 o'clock by C. L. Pillsbury. Mr. Pillsbury made a few brief introductory remarks in which he spoke of the pride of Minnesota in its university and its achievements. The main engineering building, he said, is in reality the nucleus of a group of new and very fine engineering buildings which are to surround it on the campus, constituting the College of Engineering. The Experimental Engineering Building has already been constructed, and the Chemistry Building, the third of the group, is now under way, and is expected to be when completed one of the finest in the world in point of equipment and design for the purpose for which it is intended. A new Electrical Building and a new Mechanical Engineering Building will be the next in order.

Mr. Pillsbury then introduced the Hon. Fred B. Snyder, Senator, and Regent of the University. Mr. Snyder briefly recounted the history of the State, from its beginning as French territory to its entrance into the Union as a full-fledged State. He said that he was born in the first house built on the other side of the Mississippi River and was a baby in his mother's arms at a time when it was not infrequent to see Indian faces peering in at the window. If so much can be done in a community in fifty years, what will the next half century have to show in the way of progress? He spoke further of the architectural plans of the University and of how in 1863, to liquidate its indebtedness, a committee of citizens voluntarily offered their services to prevent the forced sale recommended by the legislature. He also said that the State owed much to the pioneer New England stock who formed its first colonists.

Prof. H. T. Eddy, Emeritus Dean of the Graduate School of the University, was then introduced. The Engineering College, he said, was unique in the United States, in that the students were almost exclusively drawn from Minnesota, and that during the past twenty years it had grown from almost nothing to a size which places it in competition with other engineering colleges. Several problems have confronted the faculty, among them how its students shall be best fitted for their profession, as a result of which an additional year has been added to the customary four, in which more strictly professional work has been included.

Mr. Snyder was then called upon again to speak of the ownership by the State of certain lands which furnish the University funds, since the University has no endowment, but is entirely dependent upon the legislature for its support. Mr. Snyder said that a fixed rate, 0.23 of a mill, is customarily levied upon the total assessed value of the State, but in addition to this a provision has been incorporated into the State organization that certain fixed lands shall be set aside for the support of education. There are also certain lands which have come by way of grants from the Government which are used for the same purpose. Many of these are mineral lands, which are leased to operating parties, and the royalty derived is devoted to the University.

H. G. Reist, Vice-President, representing the Council, then took the chair and made a few brief remarks on the inspiration such an active community as the Twin Cities afforded to visitors. He had been particularly impressed with the valuable property set aside for park purposes as well as with the beautiful buildings, and with the fine state of preservation of the river banks. On behalf of the Society he thanked the local members for their efforts in arranging for so interesting a program and for their welcome to their community. He then said that he thought the meeting would be interested in the fact that the Society's president, Mr. James Hartness, had been detained from the Convention because Yale was honoring him with the degree of Master of Arts, which required his presence in New Haven. It was moved and seconded by the meeting that the following telegram of congratulation be sent to President Hartness:

The members of The American Society of Mechanical Engineers have learned with great satisfaction of the distinguished honor of the degree of Master of Arts which has been conferred on you by Yale University, and wish to express not only their congratulations to you but that you should have brought such distinction to the profession.

The technical papers of the session were then presented.

At the conclusion of the session a buffet luncheon was served in the Experimental Engineering Building, at which the ladies were also present. The following resolution of thanks was passed at the luncheon:

Whereas, The American Society of Mechanical Engineers, assembled in convention from June 16 to 19, 1914, at St. Paul-Minneapolis, Minnesota, has received a most cordial and spontaneous welcome from the members and friends of the Society in these Twin Cities and vicinity and has enjoyed the results of the tireless efforts and faultless preparation of the local committees, and

Whereas, the visiting members and guests have been the recipients of the delightful entertainment so bountifully provided, and have had the opportunity to visit places of marked technical interest;

Be it Resolved: That on behalf of the Society, visiting members and guests, a vote of thanks be extended to all who have participated in these substantial evidences of friendship and good-will, with the assurance that such a formal resolution as this is but a poor and outward symbol of the deep feeling of gratitude which each visitor personally feels for

the hospitality so generously extended; further, that the Secretary be instructed to extend thanks by written letter, to the local Executive Committee, the Ladies' Committee and the other local committees; and to all individuals and organizations that have contributed to our entertainment including the educational institutions and clubs of the cities; and in special measure to Mr. Gebhard Bohn for the invitation to his home for this afternoon and evening.

RECEPTION AT RESIDENCE OF MR. GEBHARD BOHN

Immediately after luncheon the members and guests were conveyed by special train to the residence of Mr. Gebhard Bohn on Lake Minnetonka, where elaborate preparations had been made for their entertainment. Mr. Bohn's residence, one of the most beautiful on the Lake, has an ideal location on a peninsula which gives it the advantages of an island, while it is nevertheless connected with the main land. The grounds, which are finely laid out, were thrown open to the visitors and everything possible arranged for their enjoyment and comfort. A platform was erected at one end of the grounds for dancing, and entertainment of a professional nature was also provided. Daylight fireworks also delighted the guests, and much amusement was furnished by a silhouette artist who caricatured prominent members of the Society who were present as well as local celebrities. Supper was served about 6 o'clock.

EXCURSIONS

The Local Committee had arranged an attractive list of excursions to inspect industrial developments in the vicinity of St. Paul-Minneapolis and a neat brochure was issued relating to these. Perhaps of first interest was the High Dam across the Mississippi between the two cities, a description of which was given in one of the papers presented, but unfortunately high water in the Mississippi at the time of the Convention endangered the coffer dam and the incompleted structures so that the inspection of the work there could not be made.

Among other public institutions or plants to be visited were the new States Prison at Stillwater, having a mechanical equipment of great magnitude, including not only a central power plant and distribution systems for water, heat, light, etc., but complete manufacturing equipment, signal systems, refrigerating plants, etc. A trip was arranged to the main power plant of the Twin City Rapid Transit Company having twenty-five 550-h.p. boilers and several turbines of large size, besides water power equipment. Other power plants inspected were those of the Consumers Power Company, the St. Paul Gas Light Company and the Minneapolis General Electric Company.

There were also, of course, the great flour mills, located near the Falls of St. Anthony on the east bank of the Mississippi, where within a space of eight square blocks is to be found the largest milling center in the world. In this district are 22 of the 26 mills in operation in the city of Minneapolis, among these being the Washburn-Crosby, Pillsbury, and the North Western Consolidated, with a daily output of 77,000 barrels of flour. The modern and highly efficient character of the machinery employed in the mills is illustrated by the fact that the Washburn-Crosby Company has recently scrapped a power plant costing $30,000 in order to replace it with the most modern equipment.

The industrial plants visited in St. Paul included that of the White Enamel Refrigerator Company, manufacturing house and special refrigerators and the refrigerator equipment for refrigerator cars. There are now about 70,000 of these cars in operation in the United States and Canada and all of the fruit and vegetables raised on the Pacific Coast are transported in them. A second plant of this company, the Northern Insulating Company, is devoted to the manufacture in immense quantities of flax fiber for insulation for refrigerators, the processes of which are unique.

At the American Hoist & Derrick Company, manufacturers of derricks of all descriptions, hoisting engines, electric hoists, locomotive cranes, railroad ditchers, log loaders and wire rope clips, the actual working of a railroad ditcher was shown. Griggs, Cooper & Company, with an equipment for making crackers and candy, the Waldorf Box Board Company, which has a tonnage of about 300 tons per day, and the Crex Carpet Company were also thrown open to visitors.

In Minneapolis, the trips included the Minneapolis Steel & Machinery Company, making a variety of products from steel bridges to the smallest of iron and steel castings. The tractors made by this concern are a departure in farm implements, designed to replace the horse in routine plowing, harrowing and hauling for farm work. Visits were also made to the North Star Woolen Mills and the North Western Knitting Company.

During the convention the ladies were shown about St. Paul and Minneapolis in automobiles and given every opportunity to see the many attractions of the locality. Each guest was presented with a souvenir of the convention, in the form of a small silver coin purse.

DULUTH EXCURSION

After the close of the convention on Friday, about forty members availed themselves of the opportunity to visit the city of Duluth, in response to the invitation of the local members, represented by T. W. Hugo. The visitors were shown the harbor of Duluth by moonlight on Friday evening, and on the following day viewed the large ore-handling apparatus of the city.

THE HANDLING OF COAL AT THE HEAD OF THE GREAT LAKES

BY G. H. HUTCHINSON,[1] ST. PAUL, MINN.

Non-Member

An industry of such importance as the handling of coal on the Great Lakes is of interest from an historical as well as a mechanical view point, so that it has seemed well to trace briefly the growth of the traffic and to give step by step the gradual development of the mechanical coal handling devices from the simple beginning to the present elaborate installations.

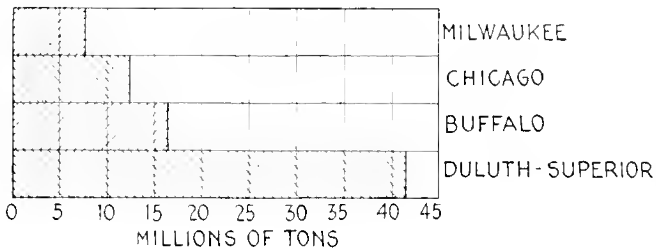


Fig. 1 Diagram showing tonnage handled at twin ports of Duluth-Superior, Chicago, Milwaukee and Buffalo

greater dispatch and with less confusion and congestion than would be possible by rail. The transportation annually of many million tons of iron ore, copper and coal, of large quantities of manufactured goods, and immense grain crops from tributary territory has resulted in the building up of several natural centers of distribution of considerable magnitude. Among these in order of tonnage are the twin ports of Duluth-Superior, Chicago, Milwaukee and Buffalo, together with a large number of other ports of importance on the lower and upper lakes, Fig. 1. The Great Lakes not only facilitate the distribution to consumers of the products of the mines, the soil and the factory, but make possible the bringing together, at a minimum cost for transportation, of millions of tons of iron ore and coal, a factor of importance in the cheap production of steel.

The Duluth-Superior harbor at the head of the

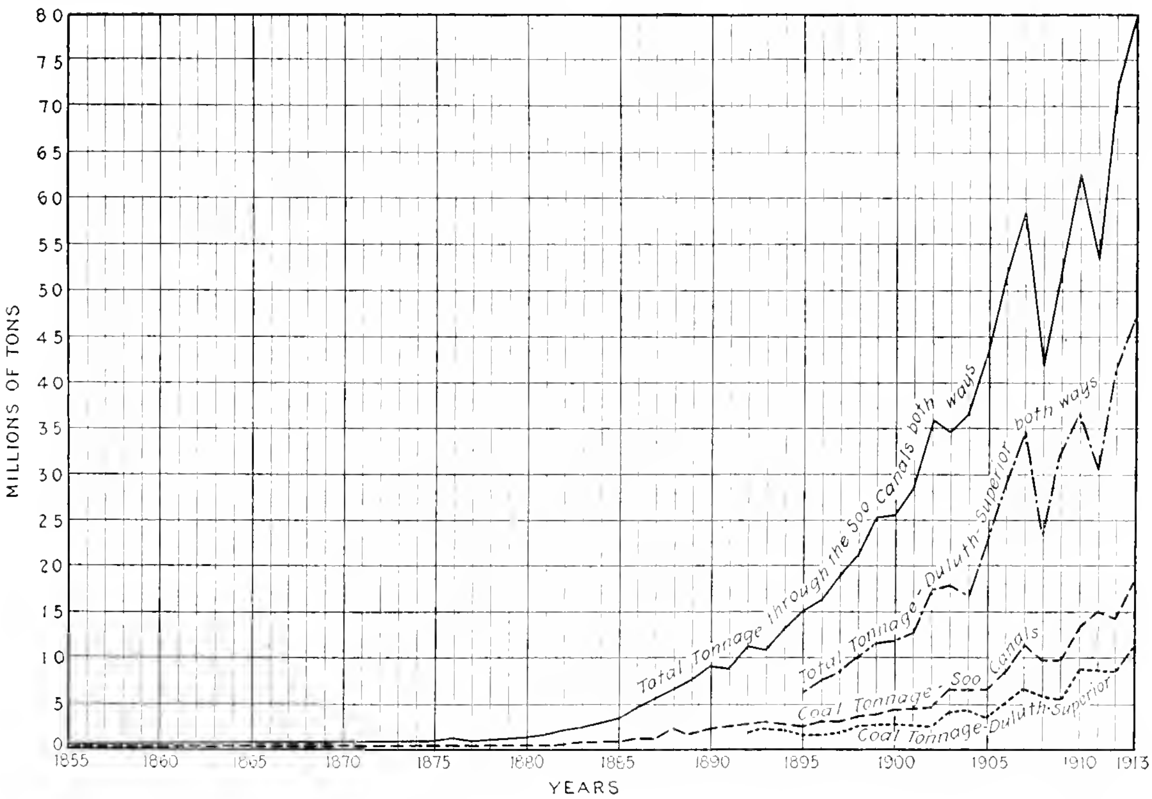


Fig. 2 Diagram showing marked increase in coal trade and of lake and rail traffic of all kinds

The natural waterway formed by the Great Lakes, extending for 1000 miles from Buffalo to the head of the lakes, not only affords cheap transportation, but facilitates the handling of enormous tonnage with lakes is not only the natural distributing point for the Northwest, but the harbor itself is unsurpassed, considering the essential features of safety, size of harbor, length of shore-line, and the large easily improved area available for dockage.

The shipment of coal to the Northwest by way of the Great Lakes began as far back as 1855, when about

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Presented at the Spring Meeting, St. Paul-Minneapolis, 1914, of The American Society of Mechanical Engineers.

1411 tons passed through the Soo Canal. Little, if any, of this was taken to Duluth and Superior, as the bulk of it went to the copper country in Michigan. It remained for Mr. E. N. Saunders, for many years president of the North Western Fuel Company, to conceive the idea that coal could be easily and cheaply carried by way of the Great Lakes through the Soo to this northwest territory, so much in need of good fuel at reasonable prices. In 1871, he brought up the first cargo of commercial coal ever unloaded in Duluth, and his total shipments during that year were about 3000

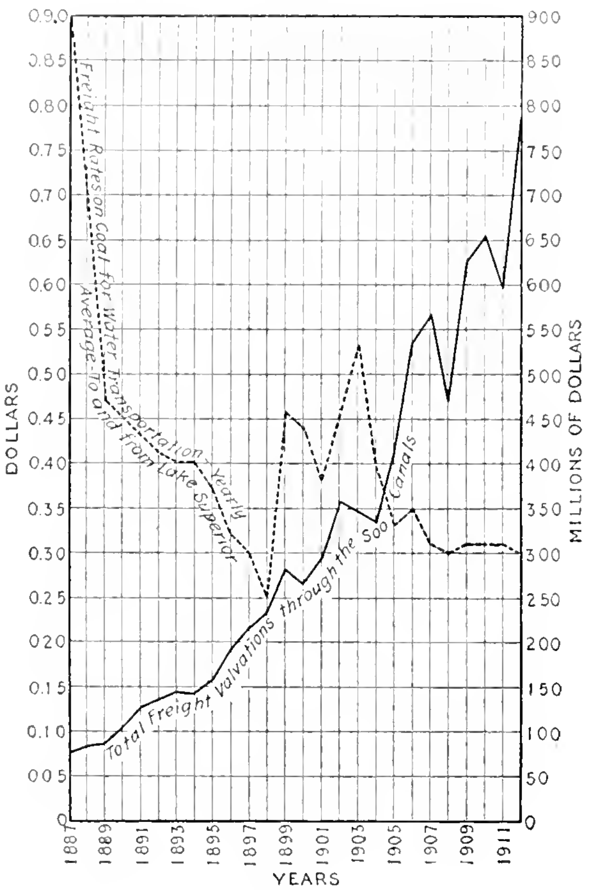


FIG. 3 DIAGRAM SHOWING ESTIMATED ANNUAL VALUATIONS OF FREIGHT PASSING THE SOO FROM 1887 TO 1912

tons. This enterprise was conducted by Mr. Saunders personally for a period of about four years, during which time he had no dock and the coal was unloaded for him, either by the railroad company or by B. S. Russell, a dealer in Duluth. The coal was not stocked, but was reshipped direct by rail. The coal business having grown to somewhat large proportions, the leading coal dealers in St. Paul and Minneapolis formed an association in 1875 to handle coal at Duluth, which in 1877 was organized as the North Western Fuel Company. J. J. Hill was the first president and E. N. Saunders was the general superintendent. The same year, a dock was secured at Duluth and equipped for handling coal.

The increase in tonnage of coal distributed through the Northwest is perhaps the best index of the growth of this section of the country, as coal is used almost exclusively for fuel for domestic and power purposes in the cities, and for locomotive firing, and is also in general use throughout the farming districts. To a limited extent, Eastern coal shipped by lakes is distributed as far west as the Pacific coast. The growth of the coal traffic, which has been very rapid within the past few years, will be further augmented by the general growth of the Northwest, the demands made by the mills of the Minnesota steel plant now nearing completion, and by industries which will be established near the steel plant with a view to the fabrication of its output. The demand for coal will be further increased by the decreasing available supply of wood for fuel.

The kinds of coal transported by water for distribution through the Northwest comprise the various grades of bituminous and anthracite and the several intermediate grades of coal from Pennsylvania, West Virginia, Ohio, Maryland and Kentucky; the bituminous coal from Illinois and Iowa and other states being distributed by rail. Briquets for both power and domestic purposes are also being manufactured in considerable quantities at Superior from anthracite dust and Pocahontas smokeless screenings.

The marked increase in the coal trade, as shown in the diagram in Fig 2 and of lake and rail traffic of all kinds, has called for radical development in the means for lake and rail transportation, and in the harbor and other terminal facilities, and the writer believes that the statement is justified that this demand is being met in an adequate manner. As in other lines of activity, the increased volume of business and the development of facilities are mutually dependent, each making the other necessary and possible. In considering the extensive and highly developed equipment of today required by the large tonnage handled, we should not lose sight of the fact that the primitive methods and equipment may have been as well adapted, all features considered, to the primitive conditions and to handling the tonnage of the early days, as the modern methods and equipment are suited to the present conditions and demands. The dispatch which is required in handling large tonnage, is the chief element justifying as well as demanding present day equipment and facilities, for when ultimate economy is considered, the gain is apparent rather than real, as the cost of actually handling coal is but a small percentage of the total cost, including initial investment, maintenance and other overhead charges. This development of facilities has not been restricted to any individual feature, but has been general and applies to methods of mining, preparation of coal at mines, transportation to lake ports, loading to vessels, water transportation, and the unloading and other handling operations at the receiving docks.

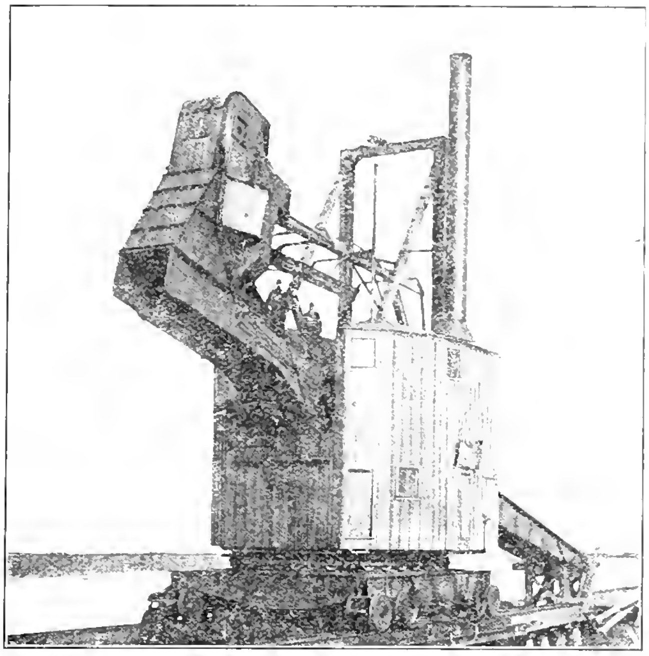


Fig. 4 First End Car Dumper, designed by G. H. Hulett, installed at Ashtabula, Ohio, in 1893

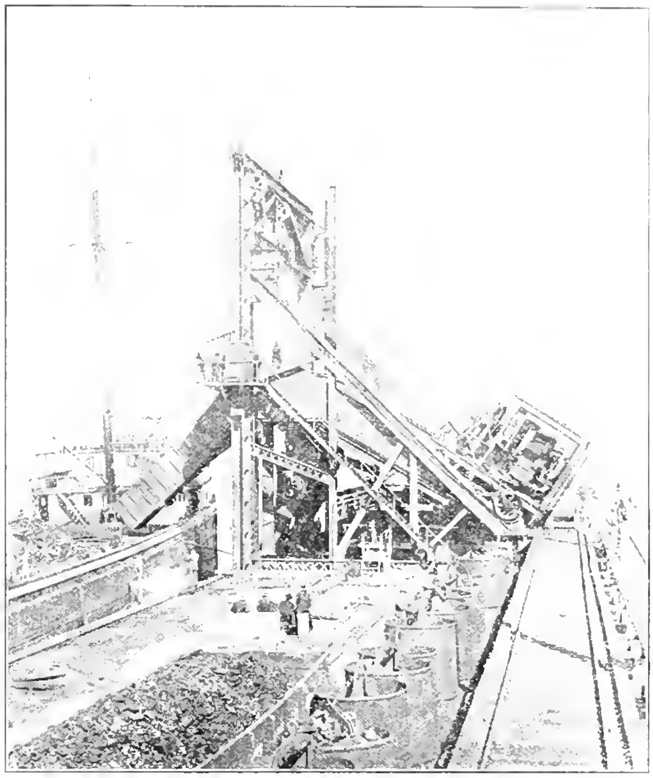


Fig. 7 Thornburg Car Dumper, built by Webster, Camp and Lane, 1896, and installed at Sandusky, Ohio

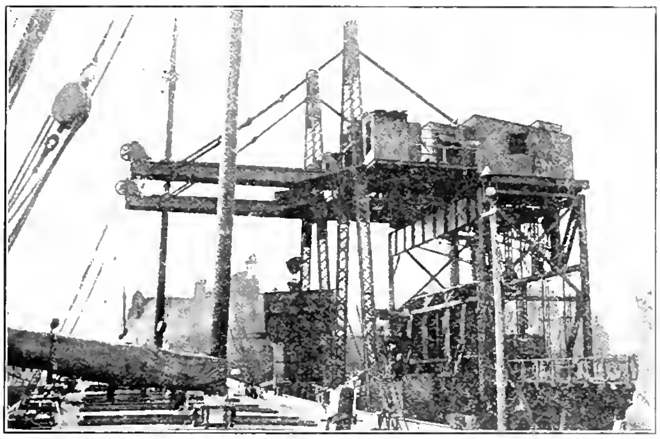


Fig. 5 Hulett Car Dumper, installed on Buffalo, Rochester and Pittsburgh Dock about 1898

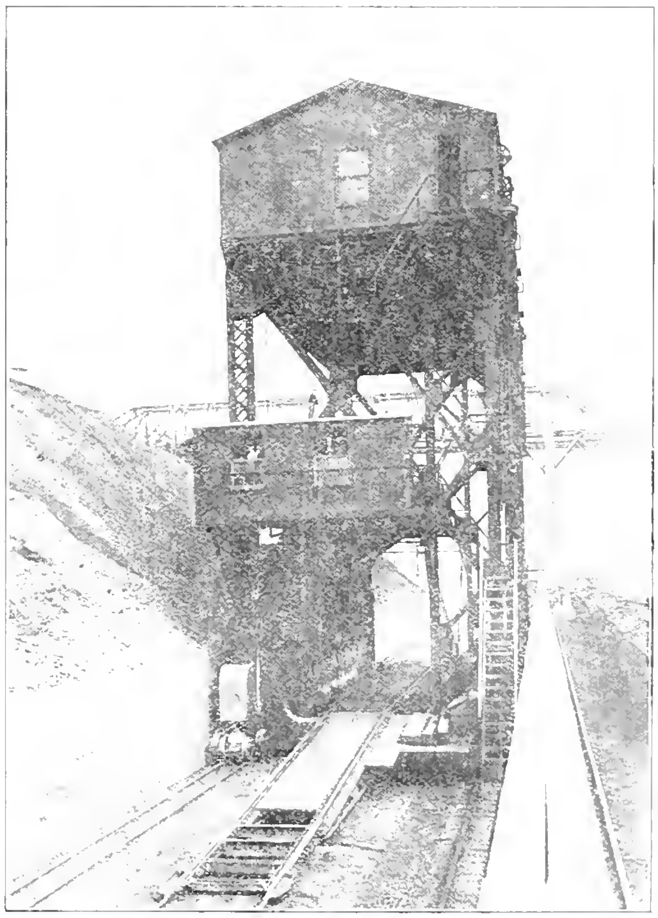


Fig. 8 Hulett Traversing Car Dumper, built by Wellman-Seaver-Morgan Company for Stocking Iron Ore at Pittsburgh Steel Company's Plant, Monessen, Pa.

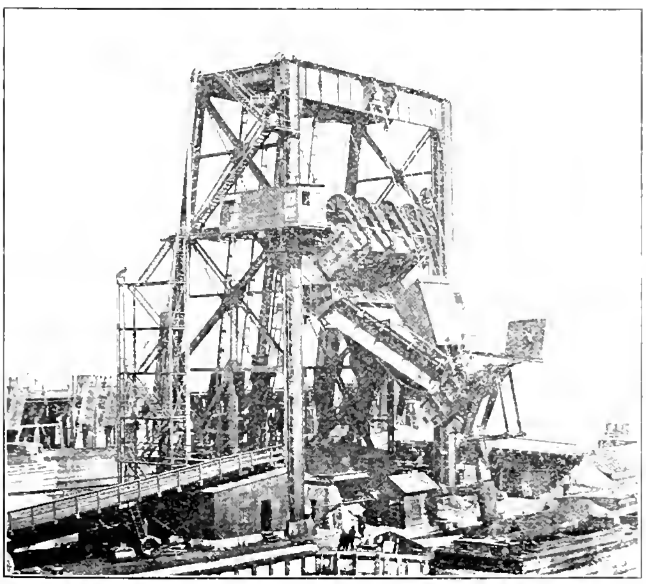


Fig. 6 McMyler Car Dumper, Philadelphia, Pa.

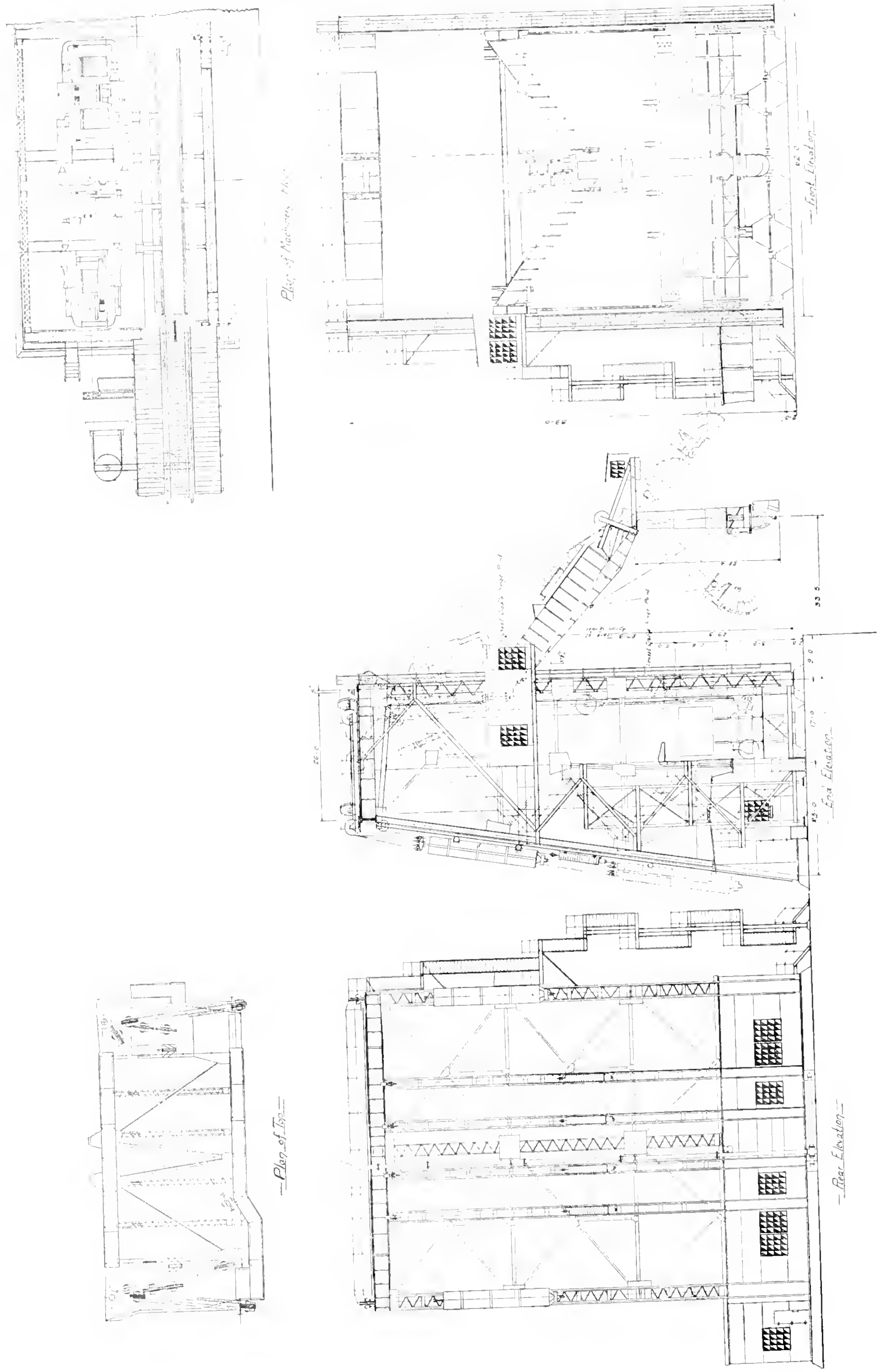


Fig. 9 McMyler Car Dumper built in 1913 for Pittsburgh and Conneaut Dock Company

DEVELOPMENT OF TRAFFIC ON THE GREAT LAKES

The degree in which lake vessels have responded to the demand of increasing traffic becomes evident when we consider that 40 years ago the lake craft was made up largely of wooden schooners of 300 tons to 700 tons burden, at which time the total annual tonnage passing through the Soo canal was less than 900,000 tons. In 1912, out of a total of 853 freight carriers, there were 127 vessels between 500 ft. and 600 ft long, having carying capacity of from 9000 to 11,000 tons; and 12 vessels over 600 ft. long, having a carrying capacity of betwen 11,000 tons and 14,000 tons. The total tonnage pasing the Soo canal in 1913 was nearly 80,000,000 tons. Fig 3 shows the estimated annual valuation of freight passing the Soo from 1887 to 1912, showing an increase of slightly more than 1000 per cent during 25 years. The coal passing through the Soo canals in 1855 was 10 per cent of the total tonnage for that year; in 1912 the percentage was 20.6 per cent.

The gradual reduction of freight rates for water transportation of coal to Lake Superior for 25 years is also shown in Fig. 3, from which it will be noted that the rate in 1912 was 30 cents per short ton, or only one third of that in 1887.

Forty years ago, it was necessary to guarantee return cargo for a boat, before chartering it for a trip to the head of the lakes. At the present time, however, the eastbound shipments from Lake Superior are about three and one-fourth times as large as the westbound shipments, with the result that many boats engaged in the iron ore trade return light on the westbound trip.

The increasing tonnage of coal handled from mines to lake and seabord ports has, in conjunction with the iron ore traffic from the lower lake ports to furnaces, led to the introduction of railroad cars of large capacity, with corresponding development of track and motive power, until today there are several hundred 90-ton cars in service on at least one road, transporting coal to seaboard, which is from six to twelve times the size of coal cars of 40 years ago, and provision is now being made at the docks for handling still larger cars.

TRANSFER OF COAL FOR LAKE SHIPMENT

The transfer of coal at the lower lake ports is ordinarily made direct from cars to boats without stocking. Prior to 1892, coal was loaded to boats from railroad cars either by wheelbarrow or by simple derricks equipped with small tubs, into which coal was dumped or shoveled, depending upon the kind of cars. In about 1892, however, the first successful car dumper (Fig. 4) was built at Ashtabula on Lake Erie for dumping the entire contents of gondola cars into vessels at a single operation. This was an end dumper designed by Mr. G. H. Hulett and built by the McMyler Manufacturing Company, which tilted the car endwise, requiring special gondola cars with end doors for discharging the contents of the car into the boat. After the installation of a second similar end dumper at Fairport in 1893, there followed in rapid succession several types of side car dumpers, known respectively as the McMyler, Long, Brown, Thornburg and Hulett car dumpers or tipples, which, as the name indicates, tilted the cars sidewise and permitted the handling of all types of gondola cars, discharging the coal over the sides of the cars into a concentrating apron or hopper, Figs. 5, 6, 7, 8 and 9. So far as specified above, the process of handling the coal was much the same by the various side car dumpers, but for the remainder of the process, in which the coal is transferred from the concentrating apron or hopper to the hold of the vessel, there are three methods.

a That in use on the earlier dumpers in which the coal was discharged from the hopper direct to the hold of the boat through simple short chutes;

b That in use on several of the dumpers, built between 1895 and 1900, in which the coal was discharged from the concentrating hopper into two or more bottom dump skips of sufficient aggregate capacity to hold the contents of a car, these skips being then carried over the boat on rams or on overhead track and lowered into the hatch before dumping, with view to keepdown the breakage;

c That in use on all, or nearly all, the dumpers built within the past 15 years, and on a few earlier ones, in which the flow of the coal is measurably controlled within articulated, entirely enclosed, telescopic chutes or spouts, which are extended to the bottom of the boat for starting the pile of coal in the hold, and gradually raised as the pile is built up, thus largely avoiding free fall of the coal in order to reduce breakage.

The number of car dumpers in service is increasing rapidly, and at present there is in progress the installation of several large car dumpers designed for handling forty 100-ton cars per hour. In all the car dumpers, except a few of the very earliest ones, every precaution has been taken to avoid breakage of coal.

DOCKS FOR RECEIVING, STOCKING AND RESHIPPING COAL

At the receiving ports, in addition to the unloading of coal from vessels and loading to cars for reshipment by rail, provision is made for the stocking, during the season of navigation of about seven months, of several million tons of coal to serve as reserve stock for supplying the heavy winter demands, and also to be drawn upon for the filling of such orders, during the season of navigation, as cannot be reshipped direct

from boats without docking. The docks for receiving, stocking and reshipping of coal are built out from the shore and vary in width from about 400 ft. to about a quarter of a mile, and in length from about 1000 ft. to three-quarters of a mile. Ordinarily these docks are served by a single slip along one side, although a few of the wider docks, which are equipped for unloading on both sides, have two vessel slips for discharging cargo. The depth of water in these slips should be as much as 21 ft, and some slips have been dredged to a depth of 26 ft. or more below U. S. mean low water datum. The slips are of various widths from about 60 ft. or 75 ft. up to about 200 ft.; in the wider slips provision having been made for the passing of two of the widest vessels under tow. The storage areas are surrounded on the water sides by timber cribs, extending from somewhat below the bottom of the slip to dock level at an elevation of approximately 6 ft. above mean low water; or by combination cribs, in which the lower timber part is capped with concrete, which extends from dock level to somewhat below the surface of the water. In both types of construction, the timber cribs are ordinarily sand filled and additional stability is provided by the driving of piles in front of the front and back walls, and further in some instances by anchoring the cribs to piles driven well back in the dock area. The dock area is usually filled with sand deposited by hydraulic dredge, which gives very satisfactory results, as this method of filling insures against settlement, providing the original bottom is of suitable nature. This district is favored in having an abundant supply of river and lake sand suitable for filling purposes. The coal storage area is covered either with a hard or soft wood plank floor, 2 in. or 3 in. thick, or is paved with concrete.

The machine tracks on which the coal hoists and coal bridges and other movable equipment travel along the dock, are ordinarily of pile and heavy timber, or pile and concrete construction. For tracks on which the heavier bridges travel, 100 lb., high-grade, steel rails laid in either one or two lines are required at each truck, and when the pile and concrete construction is used, the rails should be carried directly either on continuous longitudinal timber stringers, or on wood cross ties for cushioning the rails.

The proper provision for the storage of loaded cars and empties, and the loading and weighing of cars, with sufficient additional trackage to supply dispatch in switching service, requires from two or three to five miles of railroad track per dock, and the proper serving of these tracks requires extensive belt-line facilities.

DEVELOPMENT OF EQUIPMENT FOR UNLOADING, STOCKING AND RELOADING FOR RAIL SHIPMENT

Prior to 1876, the equipment for unloading coal from vessels comprised a tub formed of a half oil barrel, which a horse, traveling along the dock, hoisted by means of ropes passing around deflecting sheaves located on the dock near the water front, and thence over snatch blocks suspended on fore and aft ropes spanning the distance between masts on the vessel, permitting the shifting of the tubs along the suspension rope from hatch to hatch. In unloading by this method, the boats, which were of 300 tons to 700 tons capacity, were required to lay up about a week. After hoisting, the coal was dumped into wheelbarrows and transferred to stock pile on the dock, for which purpose wheeling planks were provided, extending from a point over the boat to the rear side of the dock, which at this time had a width of about 50 ft to 75 ft. These wheeling planks were carried on wooden supports or horses, of sufficient height to clear the vessel rail, which, at the beginning of unloading, would be about 3 ft. to 5 ft above the dock. From time to time, as the boat rose in being unloaded, it was necessary to interrupt the taking out of coal, while the wheeling gang blocked up the several bents supporting the wheeling plank on the dock to suit the new height of boat. Delays incident to this work occupied about 50 per cent of the total unloading time. This first process is shown on Fig. 10.

In 1876, the first improvement was made at Duluth, which largely avoided this delay, permitting practically continuous work in the actual discharging of the cargo. As a consequnce of this first improvement, which resulted in greatly increasing dispatch in unloading, the lake freight rate was cut about 75 cents per ton, amounting to about 250 per cent of the present lake rate. While this change was of a very simple nature, it represents a greater saving per ton than any subsequent improvement, and in fact is one of the few developments which has resulted in marked increase in dispatch with actual reduction in cost of equipment and operation.

This revised method of unloading is shown on Figs. 11 and 12, from which it will be noted that similar but simplified equipment was used, and that the improvement resulted principally from the method of supporting the wheeling plank and of stocking the coal. The wheeling plank was placed at a fixed height of about 10 ft. above the dock, and was carried on adjustable horses placed on the deck of the boat and on a horse located on the front of the dock. As the boat rose, the wheeling plank was maintained at a constant height above the dock level by shifting the cross beams, which carried the wheeling plank on the horses, located on the vessel deck, to successively lower supports on these horses, which operation was readily performed, and without appreciable delay to unloading operations.

Another feature, which reduced the time and simplified the operation, was the method of building the stock pile, which, in the improved method, required

the wheeling plank to extend only to the crest of the 10-ft. pile at the front of the dock, from which point the pile was extended at full height to the rear of the dock, and served as support for the wheeling plank thus reducing the number of horses required. In the original method, the wheeling plank extended the full width of the dock from the start, and the coal pile was built up as the boat rose. The writer is advised by the dock superintendent, who first used this improved method at the head of the lakes, that both the original method referred to and this improved method were in general use over the lakes at the times mentioned.

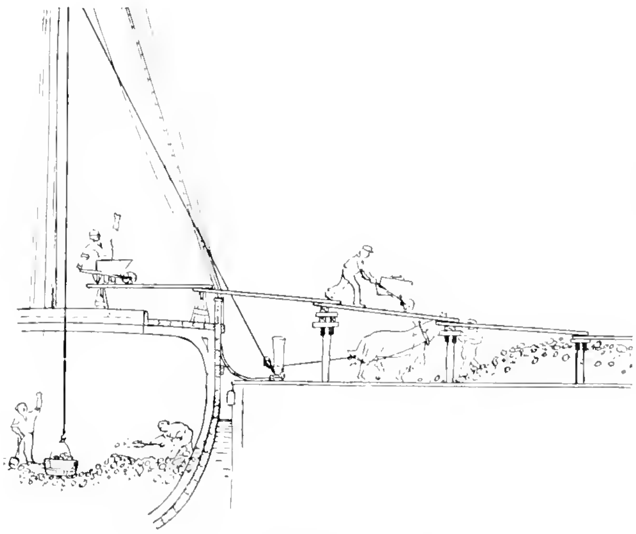


Fig. 10 Primitive Method of Unloading Coal, in General use over the Lakes prior to 1876

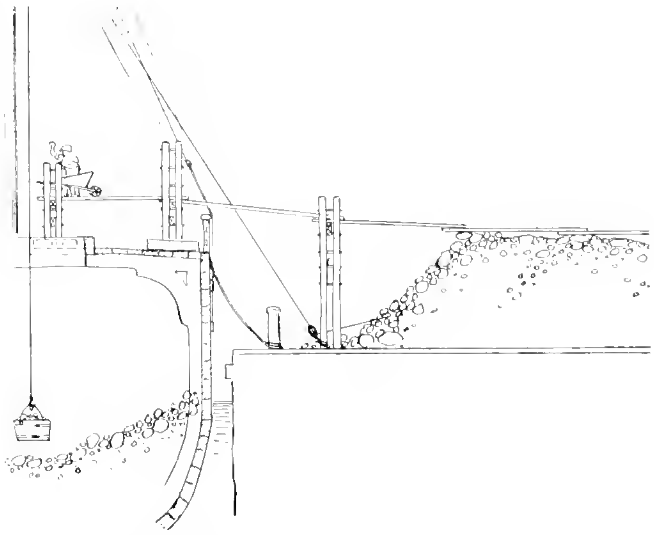


Fig. 11 First Improved Method used in 1876, in General use over the Lakes

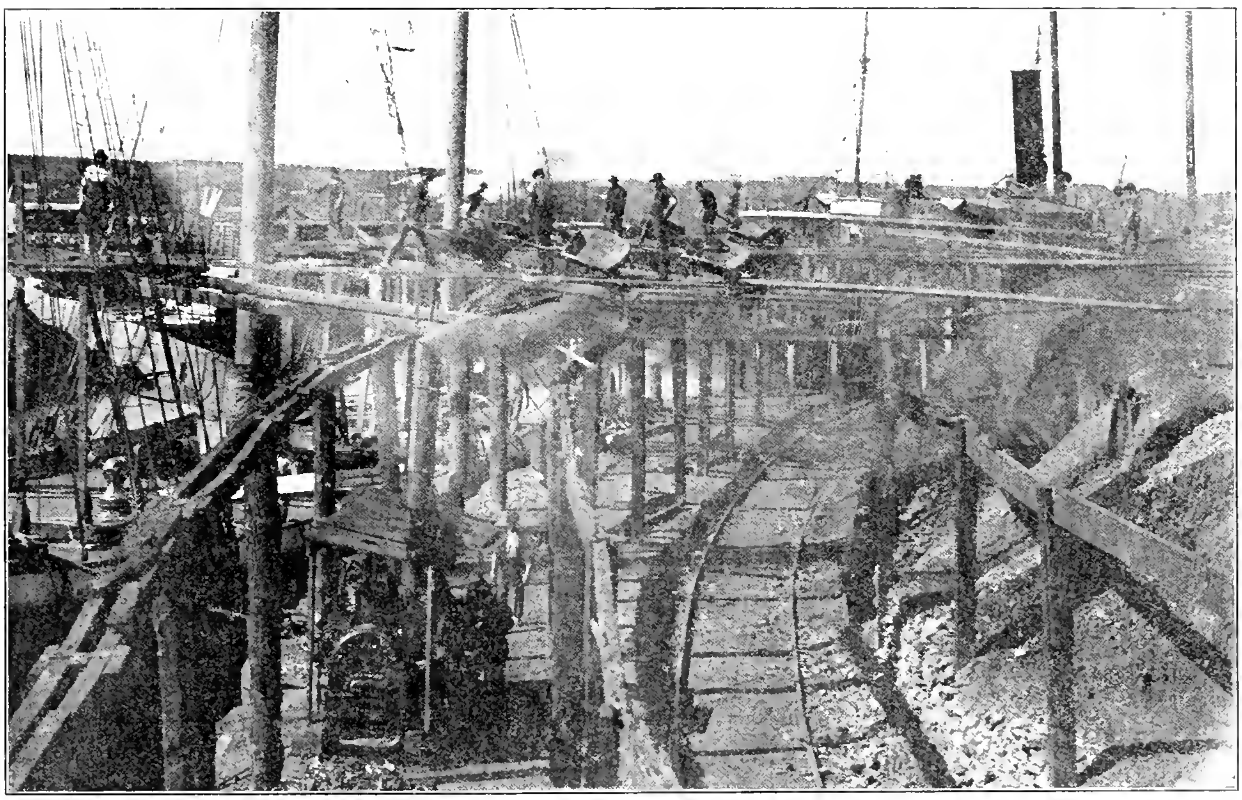


Fig. 12 Early Method of Unloading Coal and Iron Ore by Hand Shovelling and Wheelbarrow

A simple form of derrick was in use in Chicago in 1877 for the purpose of hoisting coal from boats. About 1878 or 1879, a special type of derrick was in

troduced on the North Western Fuel Company's Duluth Dock No. 1, six of which were spaced along the dock front about 66 ft. apart, and arranged for operation in pairs, it being possible to operate only one pair on a boat at a time. The tubs on the two derricks were hoisted simultaneously by means of a small hoisting engine. These derricks were similar to those still in use on some of the older docks at Duluth and Superior, and were equipped with half-ton Stuebner self-righting tubs of the same general type as the tubs now in use. Tracks were provided along a longitudinal unloading platform about 20 ft. above dock level with turnouts to tracks on transverse timber runways, on which dump cars were operated by hand, making it possible to stock the coal to a depth of about 20 ft. on any part of the dock, irrespective of the position of the boat. This gave as great flexibility in the distribution of coal in stocking as is afforded by that type of present day plant in which bulk is broken at dock front and in which separate hoisting, longitudinal transferring and stocking units are employed. This principle of flexibility was recognized in this first steam-operated plant, although it remained for later installations to perfect the structural and mechanical details.

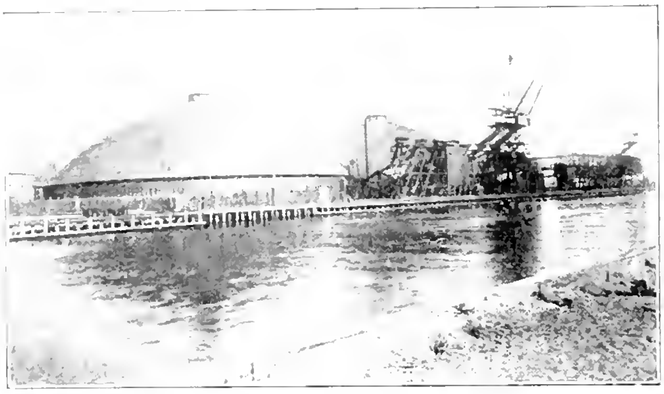


FIG. 13 DODGE COVERED ANTHRACITE STORAGE PLANT, LEHIGH VALLEY COAL SALES COMPANY, SUPERIOR

About 1881 or 1882, a third and marked improvement was made by the introduction of a main lineshaft running the full length of the dock and equipped with an individual hoist for each derrick, which permitted the independent operation of each derrick.

In 1883, a Cleveland concern installed for the Ohio Central Barge & Coal Company on its dock in Duluth, now Pittsburgh Dock No. 1, eight wooden bridges of 150 ft span, arranged four along each side of the dock and patterned after similar bridges in Cleveland. These bridges were built in pairs, with boiler and two hoisting engines located on the double pier, from which point a rope trolley, equipped with 1-ton tub, was operated on each span. They were equipped with hinged aprons extending over the boat when in service, and raised for clearing vessels when not in use. Coal was stocked 28 ft. high. The bridges were moved along the dock by hand power. These were the first coal-handling bridges at the Head of the Lakes.

Further improvement was introduced in about 1885 or 1886 in the spacing of the derricks to suit the hatch spacing on the boats, which was now becoming more uniform, making possible the working of every second hatch simultaneously without shifting the boat. About this time, also, cables were installed on the level stocking runways for pulling dump cars in both directions by power, after having been pushed from the unloading platform to the runways by hand.

Prior to the installation of the first reloading runway in about 1885, reloading to cars for rail shipment was done by wheelbarrow. From 1885 to 1888 or 1889, these reloading runways were equipped with trolleys carrying self-righting tubs. The first shovel bucket, which was made by Mr. Dole of Cleveland, was put into service at the Head of the Lakes on the Pennsylvania and Ohio dock, at present known as the Boston Dock of the St. Paul & Western Coal Company.

In 1887, nine portable, steam, timber, Hunt hoists, each equipped with $\frac{3}{4}$-ton tub and a cable railway stocking system, were put into operation on the Lehigh Coal & Coke Company's dock in Superior on St. Louis Bay, which is the North Western Fuel Company's present Dock No. 2. The hoists were located on an elevated platform at the dock front, along which they traveled from hatch to hatch in unloading vessels. These hoists were placed opposite the runways on which it was desired to stock the coal. Side dump cars carried the coal back to the stock pile by gravity, at the same time raising counterweights which returned the empty cars to the hoists for reloading. As these cars had no longitudinal movement along the dock, it was necessary to stock the coal opposite the point where it was unloaded, making in this respect a less flexible system than that last mentioned, in which derricks served by stocking cars traveling longitudinally on the unloading platform and transversely on runways were used.

In 1888, the Brown Hoisting Machinery Company installed for the Pioneer Fuel Company four steel bridge tramways on their dock on Rice's Point, Duluth, now operated by the Clarkson Coal & Dock Company. These bridges, which are still in use, have a span of 188 ft., a rear 80 ft. cantilever extension, and a hinged apron 34 ft. in length for lowering over the boat. Each bridge is carried on a tilting shear leg located at the front near the apron hinge. The two outer bridges are carried on single piers, and the two inner bridges on a double pier at the rear, spanning two railroad tracks. A boiler and four steam hoisting engines are installed on the double pier for operating the four bridges, each of which is equipped with a rope trolley carrying a 1-ton tub. The bridges are

propelled on machine tracks along the dock in part by steam and in part by hand power. The bridges are inclined with a rising grade toward the back of the dock, and are pivoted at the piers to permit skewing horizontally to suit hatch spacing.

In 1890, three similar Brown bridge tramways were erected on the Silver Creek Coal & Dock Company's dock, Superior, which was later taken over by the Philadelphia & Reading Coal & Iron Company, and now operated by the Great Lakes Coal & Dock Company. In 1893, three Brown bridges of the same type were erected on the Pennsylvania & Ohio Fuel Company's dock at Duluth, which later came into the hands of the Boston Coal & Wharf Company. In 1899 a single additional bridge was installed on this dock, this last bridge being one of the latest installations, if not the last one, where tubs were used exclusively, or before the introduction of clamshells.

In 1893, the McMyler Manufacturing Company installed several steel bridges, of 180 ft. span with 100 ft. cantilever, on the dock of the Youghiogheny & Lehigh Coal Company, Superior, on which tubs were at first used but later replaced by $1\frac{3}{4}$-ton clams. This dock is now known as the Pittsburgh Dock No. 3, and is operated by the Reiss Coal Company. The Mead Company, in about 1895, installed on this dock an automatic car and cable railway system.

In 1896, the McMyler Manufacturing Company installed several stationary timber steam hoists, fitted with steel booms and equipped with rope trolley carrying clamshell grab bucket, on the dock of the Lehigh Valley Coal Sales Company at Superior.

In about 1899, four steel suspension cable tramways, operated by Lidgerwood hoisting engines, were installed on the Lehigh Coal & Coke Company's dock, Superior, which had already been partially equipped with the movable Hunt hoists previously mentioned.

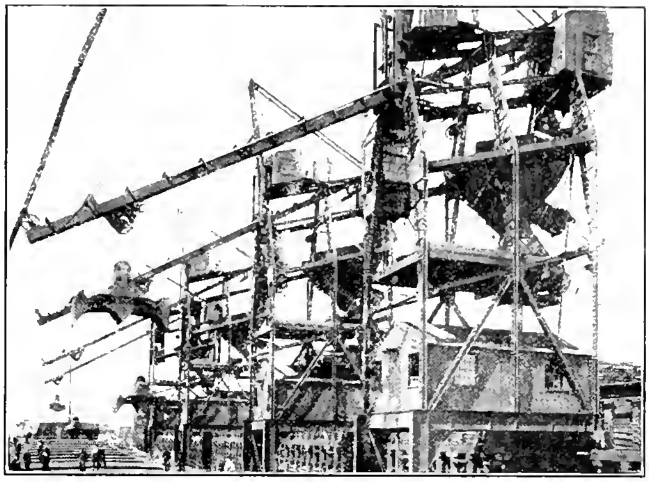


Fig. 14 Brown Hoist Towers on North Western Fuel Company's Dock No. 1, Superior, in 1902. First Electric Dock

At the time these hoists were built, or possibly a little later, they were equipped with Dole single rope clamshell buckets of about 1-ton capacity, which required hand tripping. In 1902, a fifth tramway, equipped with grab bucket, was installed by the Mead Company. Steam was furnished by main steam line from a central boiler plant at the inner end of the dock. In unloading coal was discharged into the hopper on the front pier, and stocked by means of bottom dump skips. Reclaiming was done by shovel buckets.

From 1886 to 1890 inclusive, the Dodge system of anthracite storage[1] was developed in the installation of several plants in the East, and in 1894 a 110,000-ton covered anthracite plant of this type was installed for the Lehigh Valley Coal Sales Company at Superior, comprising two units of 55,000 tons each shown in Fig. 13.

[1] Described in a paper on Hoisting and Conveying Machinery by Geo. E. Titcomb, Trans. Vol. 30, p. 123.

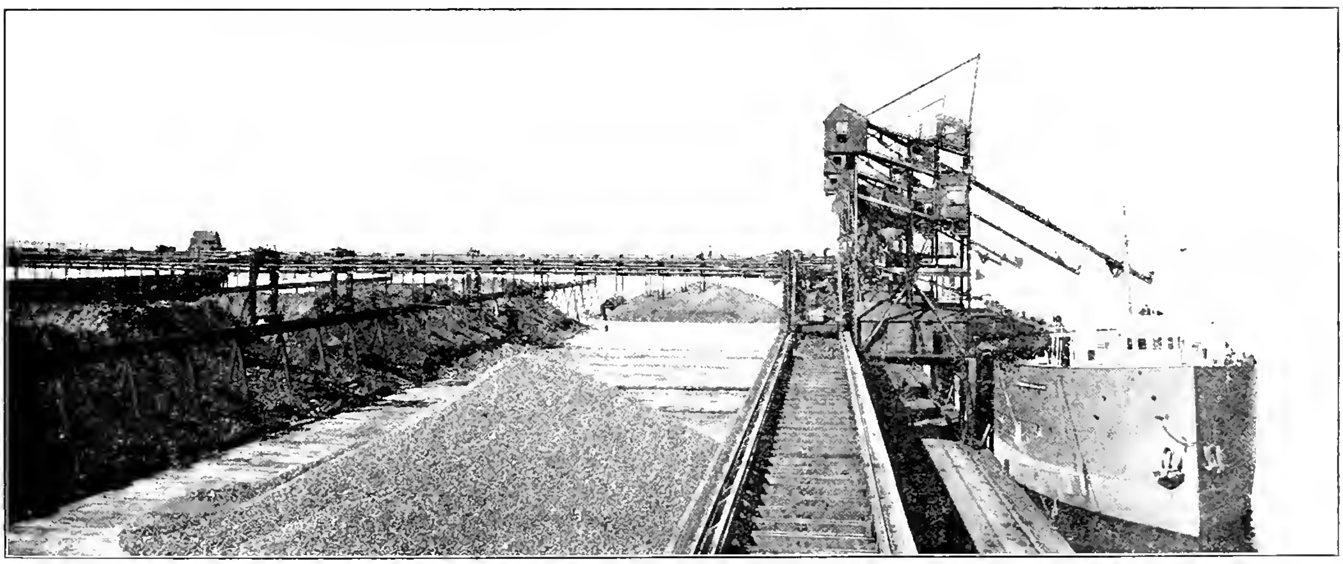


Fig. 15 Brown Hoist Towers, Bridges and Transfer Cars on North Western Fuel Company's Dock No. 1 First Electric Dock

FIRST ELECTRIC COAL HANDLING PLANT

In 1901, the Brown Hoisting Machinery Company started for the North Western Fuel Company, the construction of the first electric coal handling plant ever installed. This plant consists of four hoisting towers with one and one half ton clam shell grab buckets, later replaced by two ton grab buckets; three transfer cars; three stocking and reclaiming bridges, each having 155 ft. 2 in. spans and 42 ft. 9 in. rear cantilever, giving overall length of 508 ft. 3 in., and each equipped with one stocking man trolley, carrying a 7-ton self-righting tub, and one man trolley for reclaiming, carrying a 4-ton shovel bucket. The hoisting motors on the towers are controlled by drum type controllers and magnetic switches. Two continuous lines of timber bins are provided, one near the front end of the dock immedately in the rear of the hoisting towers, on which the transfer cars travel, and one at the rear of the dock forming support for the rear bridge tracks.

Coal is unloaded from the boat by means of the clamshell, and deposited in a 15-ton hopper in the tower. The stocking trolley with its 7-ton tub is brought by the transfer car to place opposite the tower bin, from which it receives the coal. The transfer car then runs to a bridge, with which it registers, permitting the stocking trolley to deliver coal to stock pile. The function of the transfer car is to give flexibility of operation in unloading, stocking, reclaiming and direct reshipment by rail, thus permitting the stocking of coal wherever desired on the dock, irrespective of the location of the vessel and hoisting towers, and equal flexibility in loading out.

Later a fourth bridge was added with reclaiming trolley. Direct current is furnished this equipment from a central generating system located on the dock. To relieve the generators of the high peaks, incident principally to accelerating in hoisting and traveling, a storage battery was installed, having momentary output of 2040 amperes, later increased to 2720 amperes. The rated capacity of this plant was the unloading of a 5000 ton boat in ten hours. In actual performance, however, this has at times been considerably exceeded. The construction and equipment of this dock is important, as it was the first electrically operated dock in the world; the first on which coal handling man trolleys were used; and the first coal dock on which all the operations were performed by power, making possible a new record for speed and capacity (Figs. 14, 15, 29 and 30).

In 1902, three Brown bridge tramways were installed for the Eastern Railway Company of Minnesota, and later taken over by the Jones & Adams Company. This dock is now known as Pittsburgh Dock No. 6, and operated by the Island Creek Coal Sales Company. These bridges were equipped with rope trolleys carrying 1¼-ton clamshell grab buckets, and were operated by steam.

RECENT INSTALLATIONS

In 1905, the Mead Company installed, for the M. A. Hanna Coal Company on their Superior Dock, a plant comprising three steam traveling unloading hoists, which are mounted on a longitudinal unloading platform, each equipped with a 2-ton clamshell; two 262 ft. span traversing bridges for stocking and reclaiming bituminous coal, and Mead automatic cars and cable railway for stocking both bituminous and anthracite coal. In stocking bituminous coal, the automatic cars run along tracks carried on transverse stationary elevated runways, leading to the longitudinal tracks on the bridges, giving flexibility in stocking operations. In stocking anthracite, the course of the car is confined to the elevated stationary runways

A similar installation was made by the Mead Company about the same time on the Northern Coal & Dock Company's dock, Superior.

The Zenith Furnace Company's dock, Duluth, is equipped with four Mead unloading towers handling 2-ton clams, one Mead bridge and Mead automatic car and cable railway system.

In 1906 and 1907 the Duluth and Iron Range Railroad Company's coal dock at Two Harbors was equipped with a Mead plant comprising three steam hoisting towers handling two-ton clams, and mounted for traveling on a 40-ft. high steel trestle; an electric four-ton automatic car and cable railway system; and an electrically operated stocking and reclaiming bridge handling a two-ton shovel bucket.

This dock has a storage area about 275 ft. wide by 900 ft. long, and a nominal storage capacity of about 150,000 tons. Owing to local conditions the dock does not directly face the slip, which requires the hoisting towers to operate at some distance from the storage area, giving conditions to which the portable hoist and cable railway system is peculiarly adapted.

A recent Mead installation of same general type but different in detail, made on the Washington Street dock of the Milwaukee Western Fuel Company at Milwaukee, and equipped with screening plant in bridge in place of the fixed loading bins, is shown in Fig. 16.

The stocking of coal by means of a belt conveyor on a bridge is a method used by the Robins Conveying Belt Company. In one plant of this type coal is stocked on the dock at the rate of 600 tons per hour, the conveyor having a traveling tripper for distributing the coal, which it receives from a second belt conveyor, which in turn receives the coal from a system of conveyors at the unloading towers. Reclaiming is done by a clamshell bucket at the rate of 300 tons per hour.

In 1906, a 200,000-ton covered anthracite storage plant for stocking coal 60 ft. high was installed on section 2 of the North Western Fuel Company's Superior Dock No. 1. Coal is unloaded by two Heyl & Patter-

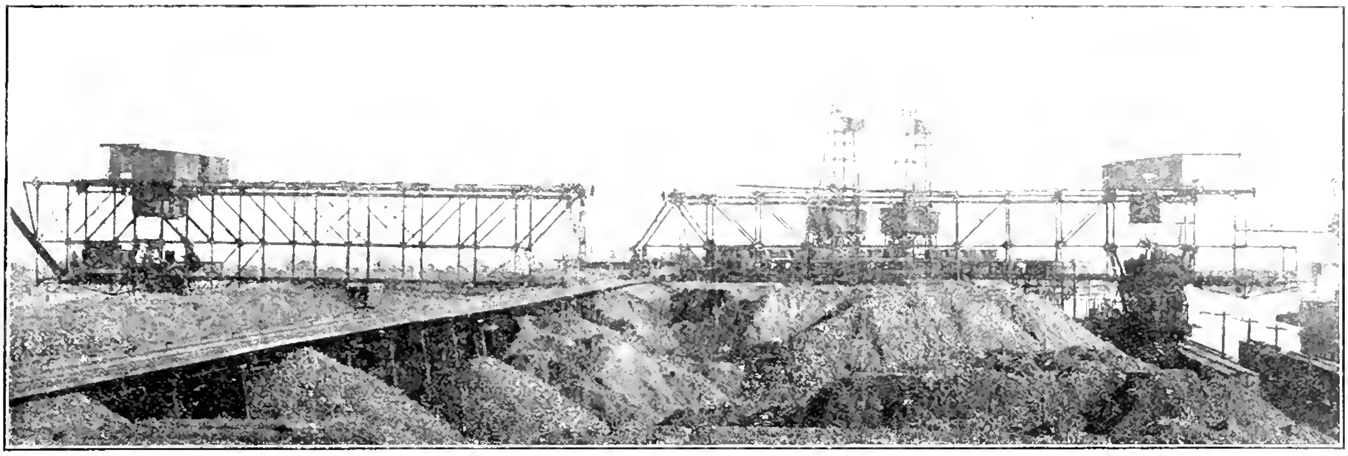


FIG. 16 MEAD HOIST TOWERS, AUTOMATIC CARS, CABLE RAILWAY AND BRIDGES, MILWAUKEE WESTERN FUEL COMPANY'S WASHINGTON STREET DOCK, MILWAUKEE

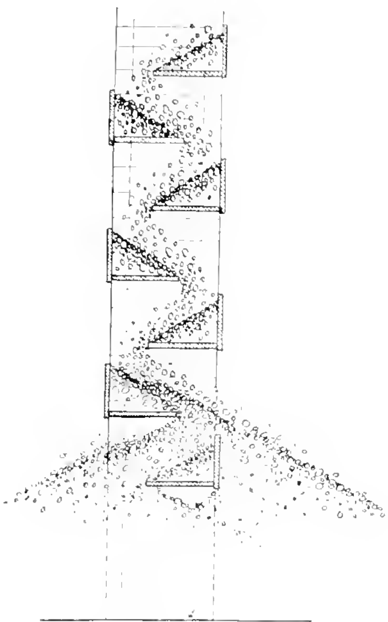


FIG. 17 HUMPHREY SHELF LOWERING CHUTE

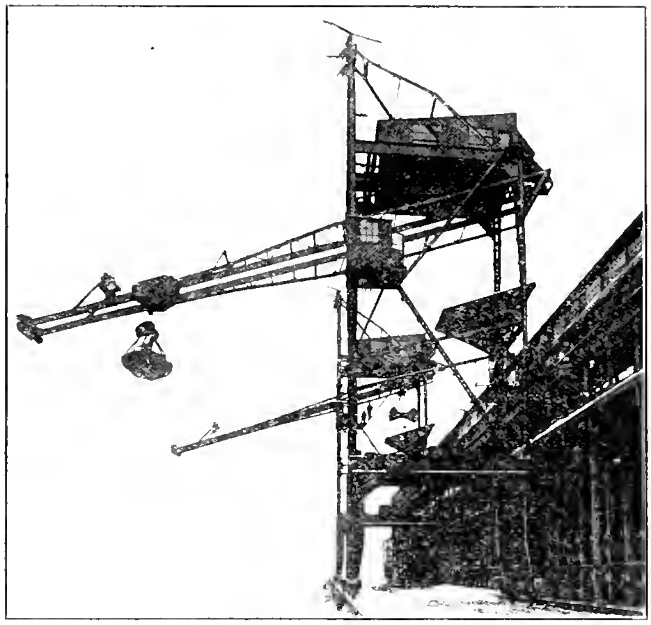


FIG. 18 HEYL AND PATTERSON ANTHRACITE HOISTS AND DODGE STOCKING CONVEYOR, INSTALLED ON NORTH WESTERN FUEL COMPANY'S SUPERIOR DOCK NO. 1, 1906

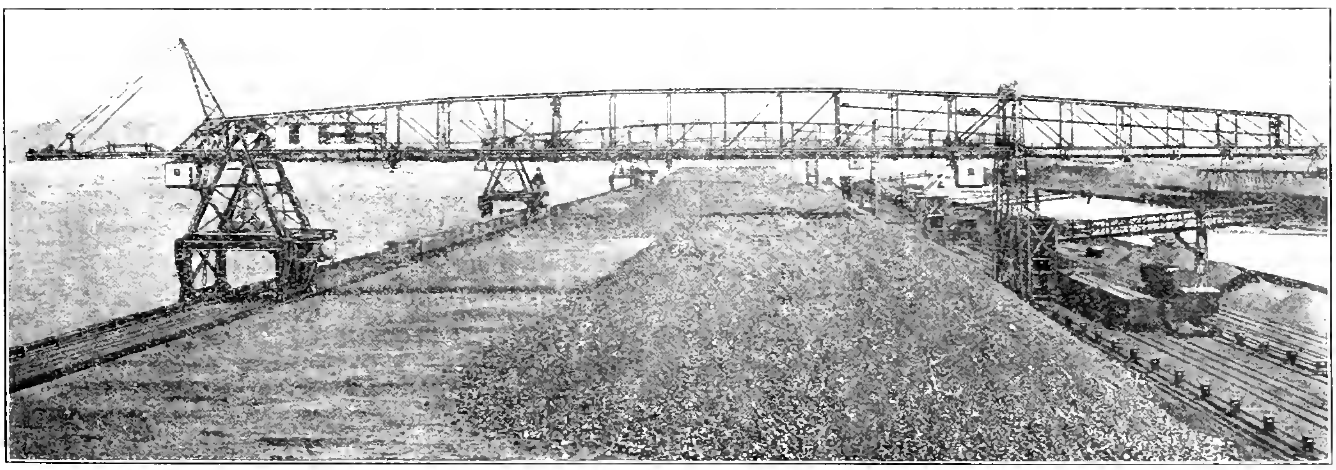


FIG. 19 DODGE COAL HANDLING BRIDGES AND AUXILIARY EQUIPMENT, BERWIND FUEL CO., SUPERIOR

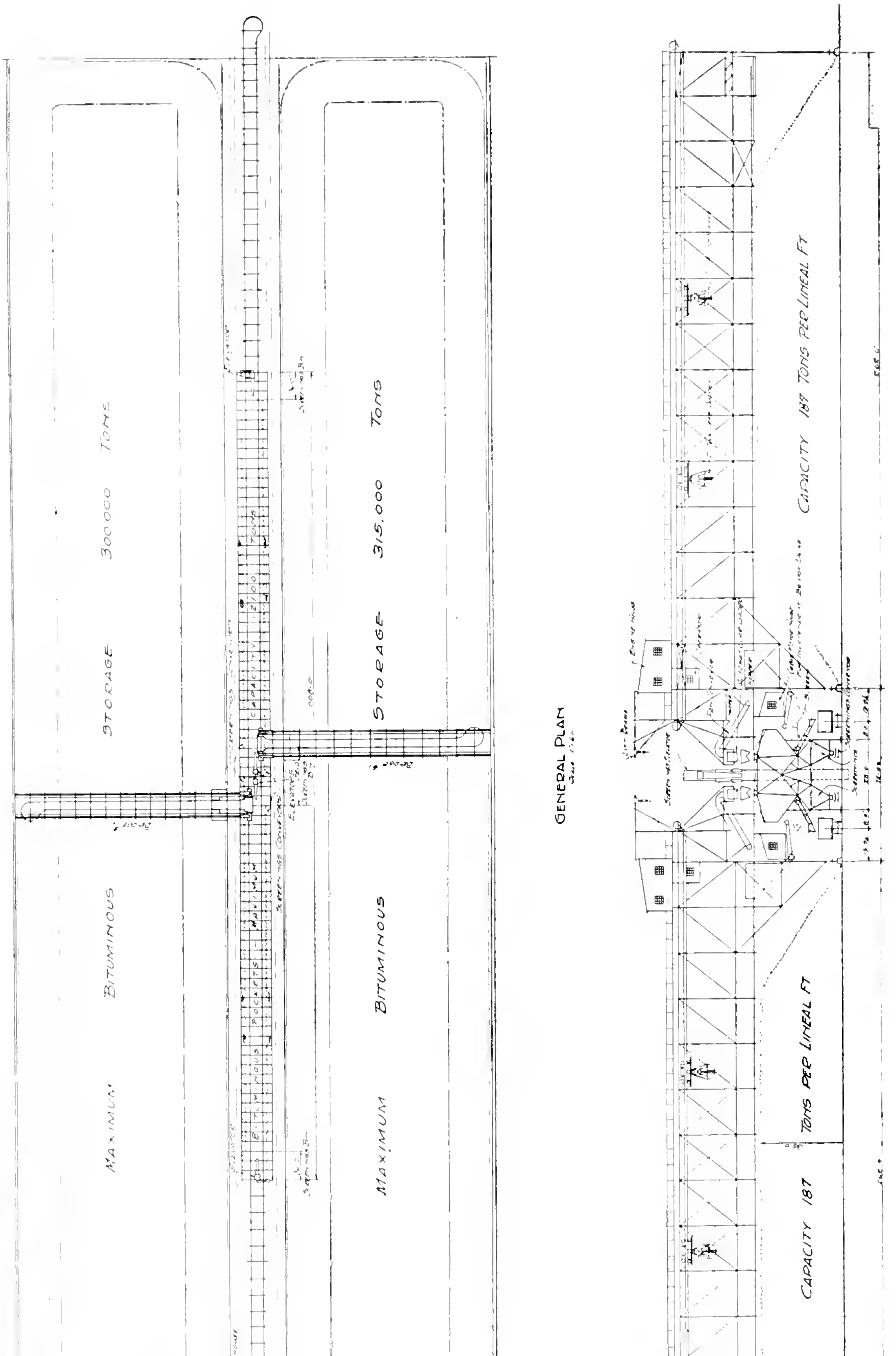


Fig. 20 Mead Hoists, Automatic Cars, Cable Railway System and Stocking and Reclaiming Bridges, Duluth, Missabe and Northern Railway Company's Dock, Duluth

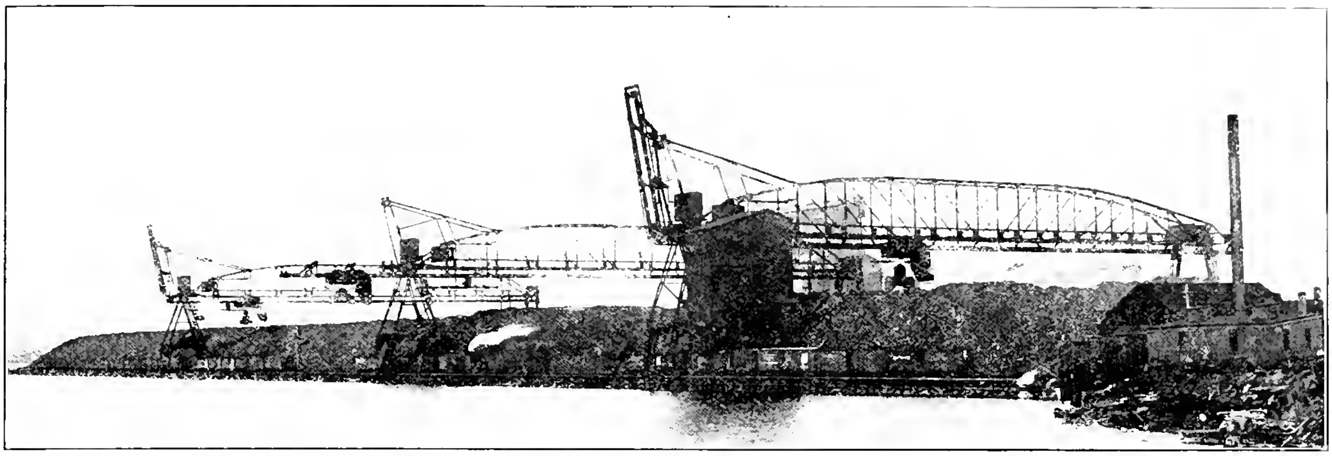


Fig. 21 Three Heyl and Patterson Bridges on North Western Fuel Company's Dock No. 2, Superior

son electric hoists, equipped with 3-ton clamshells, and stocked and reclaimed by means of Dodge reversing, electric-driven, ribbon bottom, flight conveyors of 250 and 300 tons hourly capacity. In stocking, coal is discharged from the top run of conveyors into storage building or 3000 ton shipping pocket, and reclaimed by the bottom run of these conveyors, working in tunnels beneath the coal pile. Breakage of coal is avoided, when starting the pile in stocking, by lowering the coal through Humphrey shelf lowering chutes, Fig. 17. After building the pile to full height at a single point, the ribbon bottom of the conveyor is drawn in, or extended, as the crest of the pile advances. The coal is loaded for reshipment at the single 3000-ton shipping pocket. This plant is shown on Fig. 18.

In 1907 or 1908, the Wellman-Seaver-Morgan Company installed two Hulett bridges of 176-ft. span with 130--ft. cantilever, and equipped with 2-ton grab buckets, on the Boston dock of the St. Paul & Western Coal Company. These bridges are steam operated and are provided with separate hoists and trolley engines, and controlled by two operators.

One of the larger electric bituminous coal handling bridge installations, on which the rope trolley is used, was made on the Berwind Fuel Company's Dock in Superior in 1907. Fig. 19. This is one of the later trolley installations prior to the general introduction of the large man trolley bridge. These bridges are 506 ft. long with 295 ft. span, equipped with 3-ton clamshells, and are supplemented by revolving locomotive cranes and movable screenings tower. All motions of bridge and bucket are controlled by one operator from either of two fixed control stations. All equipment on this dock is electrically operated by means of 400-volt, three-phase, alternating current.

Fig. 20 shows the Duluth, Missabe & Northern coal dock at Duluth, which is 604 ft. wide by 2000 ft. long On one half of this dock was installed in 1907 a Mead plant, comprising three portable hoists equipped with 2-ton clams, 4-ton automatic car and cable railway system, and a stocking and reclaiming bridge with 2-ton shovel bucket. Provision has now been made for similarly equipping the other half of the dock, using 4-ton clams, in place of the 2-ton clams, on two additional hoists.

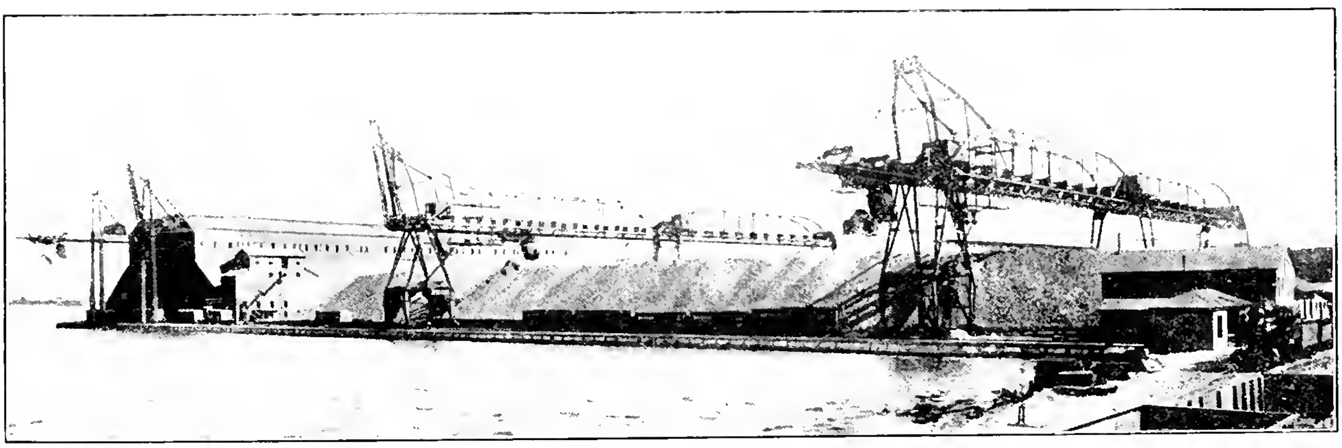


Fig. 22 Heyl and Patterson Bituminous and Anthracite Plant, Philadelphia and Reading Coal and Iron Company's Dock, Superior

ELECTRICALLY-OPERATED MAN-TROLLEY COAL BRIDGE.

The first electrically operated man trolley coal bridge, in which the unloading, stocking, repreparing, reclaiming and loading out were accomplished by a single unit, was installed by Heyl & Patterson on the North Western Fuel Company's Superior Dock No. 2 in 1909. This bridge has a span of 363 ft. 4 in. and is 155 ft. 6 in. long overall, with screening and loading out plant mounted on the shear, and run of pile loading plant on the pier. The man trolley was equipped with 5-ton Heyl and Patterson clam for unloading and reclaiming bituminous coal, this being the largest clam thus far installed at the head of the lakes. One man controls the operation of the trolley in unloading, stocking and reclaiming and bridge traversing. This bridge is operated by three-phase, 25-cycle, 440-volt, alternating current, stepped down from 13,200 volts by main transformer located on the bridge. This is the first traveling bridge to take current from high-tension trolley feeder line along the dock by means of collector shoes. The man trolley is equipped with two hoist motors and two rack motors, operated by master controllers and magnetic switches. The friction clutches and brakes are operated by compressed air. Dynamic braking is provided for racking and lowering, for which direct current is supplied by a small motor generator set delivering direct current at 40 volts.

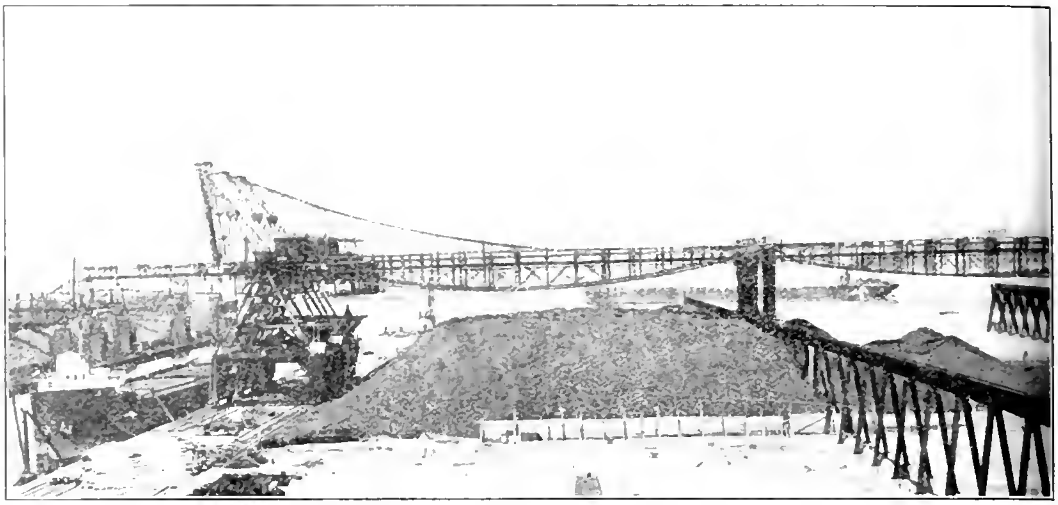


FIG. 23 BROWN HOIST BRIDGES ON PITTSBURGH

Beginning with 1909, there was an unusual development of docks and equipment, and within the next few years, ten bridges, similar to the ones just described, were installed in Superior and Duluth, as follows: two on the Carnegie Fuel Company's Dock No. 1, Superior; two on the Philadelphia & Reading Coal & Iron Company's Dock No. 2 in Superior; two on the Island Creek Coal & Sales Company's dock in West Duluth; two on the North Western Fuel Company's Dock No. 2, Superior; one on the North Western Fuel Company's Dock No. 1, Superior; and one on the Reiss Coal Company's dock—Pittsburgh Dock No. 3—in Superior. With the last bridge installed on the North

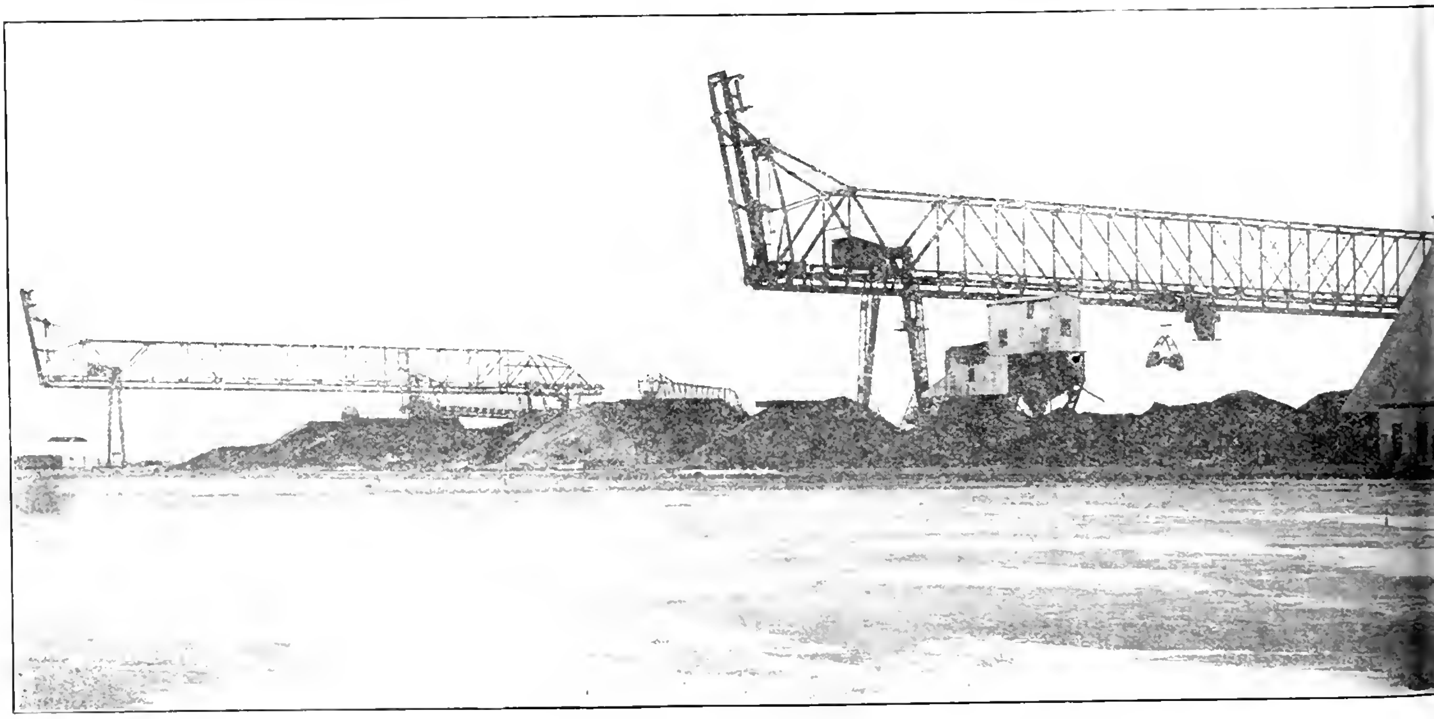
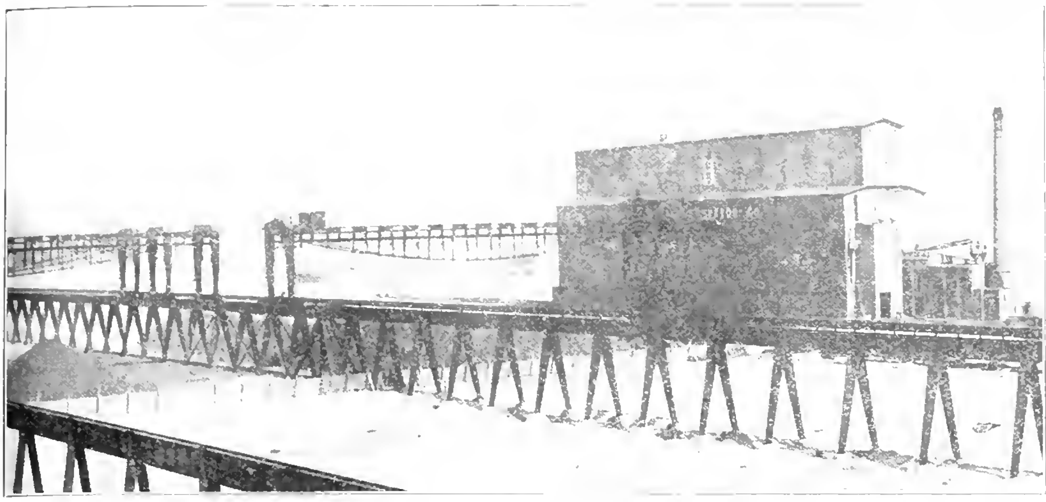


FIG. 24 PANORAMIC VIEW OF MEAD ANTHRACITE AND BITUMINOUS



Coal Company's Dock No. 7, Duluth

unloading hoists equipped with rope trolleys carrying 5-ton clamshells, a double storage building of steel construction 350 ft. by 500 ft., a mechanical screening plant for repreparation of the coal, and a shipping pocket for reloading at a single point (See Fig. 22).

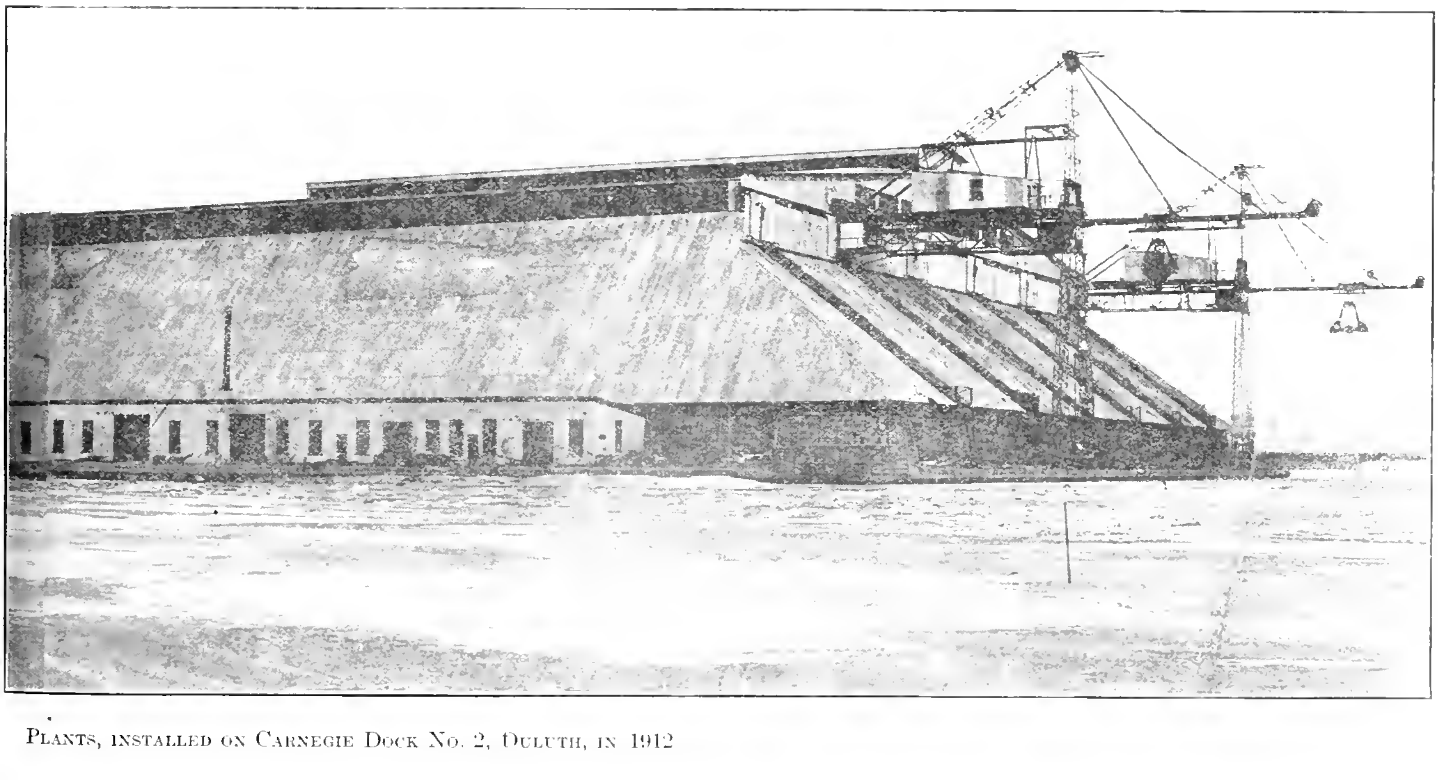
In 1910, an extension 141 ft. by 480 ft. was made to the North Western Fuel Company's Superior Dock No. 1 anthracite storage plant, in the form of a steel storage building equipped with a 3-ton man trolley, which carries a $5\frac{1}{2}$-ton skip for stocking and a 3-ton clamshell for reclaiming, with necessary additional elevators and conveyors, to supplement the original conveyor system, for transferring coal to and from the building. This gives a total anthracite storage capacity of about 265,000 tons on this dock.

Western Fuel Company's Dock No. 2 in 1912, the screening plant, which was somewhat more elaborate, was mounted on separate trucks and attached to the bridge for traveling. Fig. 21. A 6-ton clamshell was provided for this bridge, and the 5-ton clams on the other two bridges on this dock were also replaced by the 6-ton clams. In order largely to eliminate hand shoveling in cleaning up boats, after the unloading clam had picked up the coal within reach, a specially designed, 4-ton clean-up clam was developed. This clean-up clam is described in more detail in a later paragraph.

In 1910, in conjunction with two of the bituminous bridges above mentioned, there was installed on the Philadelphia & Reading Dock at Superior, an electric, covered anthracite plant, comprising two stationary

Fig. 24 shows an electrical installation on the Carnegie No. 2 Dock, Duluth, comprising two Mead bituminous bridges of 382 ft. span, and anthracite plant consisting of two traversing unloading hoists equipped with clams, and a steel storage shed 280 ft. by 404 ft. equipped with rope trolleys, operating on six runways.

An unusual arrangement of bridges was installed in 1911 on the Pittsburgh Coal Company's Dock No. 7 by the Brown Hoisting Machinery Company (Fig. 23). This installation comprises three two-span bridges on



Plants, installed on Carnegie Dock No. 2, Duluth, in 1912

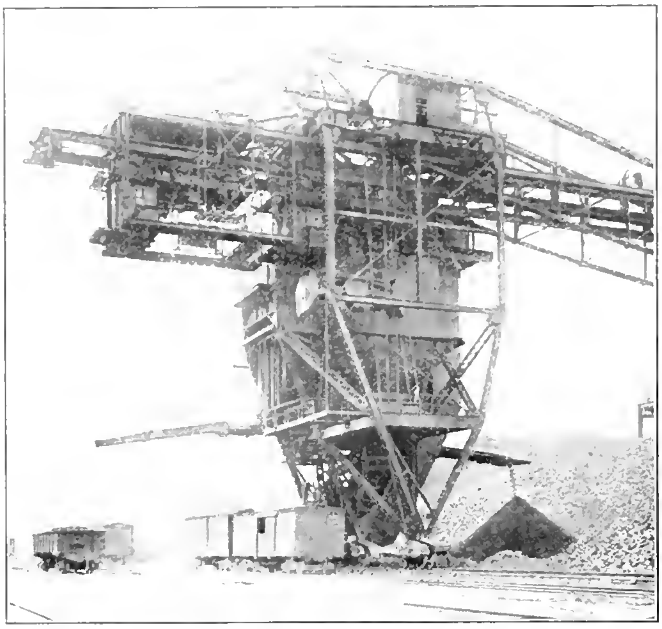


Fig. 25 Brown Screening Plant on Pittsburgh Coal Company's Dock No. 7, Duluth

the front of the dock and two single-span bridges at the rear, the spans having a uniform length of 242 ft. Each of the two-span bridges and one of the single-span bridges is equipped with a man trolley carrying a $5\frac{1}{2}$-ton grab bucket. The single-span bridges may be operated separately, or may be registered with any of the two-span bridges, thus forming continuous runways 726 ft. long across the dock; or including cantilevers and apron the overall length is 839 ft. Other interesting features of this installation are the swiveling trolley and the screening plant. The swiveling man trolley, provided with turntable to facilitate cleaning up the hold of boats, is further described in a later paragraph. A very complete screening plant, of new design and large capacity, is located in the rear pier of one of the single-span bridges, Fig. 25. This is furnished with bins, shaking and revolving screens, and the necessary elevators and conveyors for the preparation of lump coal and the separation of the degradation into nut, stove and screenings, with provision for loading box and gondola cars or returning to stock pile on the dock, as desired. Last year, a similar installation with longer span bridges was made on the Pittsburgh Coal Company's Dock No. 5 in Superior.

The coal handling plant installed last year on the Canadian Pacific Railway Company's Fort William Dock by the Wellman-Seaver-Morgan Company, consists of two automatic unloaders equipped with 8-ton scoops, a man trolley bridge carrying a 9-ton grab bucket, and a transfer car system with trestle and bins to give flexibility to the plant. Transfer cars are of 35-ton capacity, and are equipped with recording scales accurately weighing all the coal they handle. The plant has a capacity for unloading a 10,000-ton boat in 15 hours. Thirty loading pockets are provided from which cars are loaded by means of a double-ended Christy box-car loader, giving a very large loading out capacity. Fig. 26 shows a good general view of this plant.

COMPARISON OF ELECTRICALLY OPERATED PLANTS: 1902-1913

The tendency towards a few large units in the development of coal handling equipment within the past few years is shown in the comparison of the electrically operated plant installed on section 1 of the North Western Fuel Company's Dock No. 1 in 1901, and the electric coal handling bridge installed in 1913 on section 3 of the same dock, these being the first and latest electrically operated plants installed at the Head of the Lakes. The plant first mentioned has, as previously described, four hoisting towers and four bridges with the necessary transfer cars, having rated capacity for unloading a 5000 ton boat in 10 hours, and serving a dock about 560 ft. by 1100 ft. on which bituminous coal is stocked 30 ft. high. The second installation referred to, on section 3 of this dock, consists of one Heyl & Patterson bridge having a single span of 551 ft. and being $712\frac{1}{2}$ ft. long overall, on which is operated a man trolley equipped with a 12-ton clamshell for unloading, stocking and reclaiming, and 6-ton clean-up clam. This bridge serves a section of the dock about 610 ft. by 750 ft. and stocks bituminous coal to a height of 50 ft. Coal is reloaded to cars at both ends of the bridge and rescreened, when desired, at the pier end. Provision has also been made in the construction of the bridge for the future installation of a more elaborate detached screening plant for re-

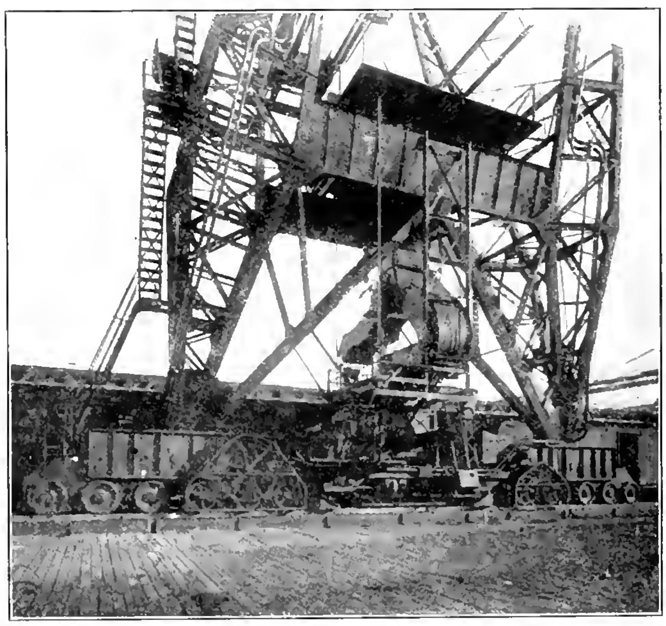


Fig. 27 Loading Plant and Trucks at Shear End of North Western Fuel Company's Bridge No. 5, Dock No. 1, Superior

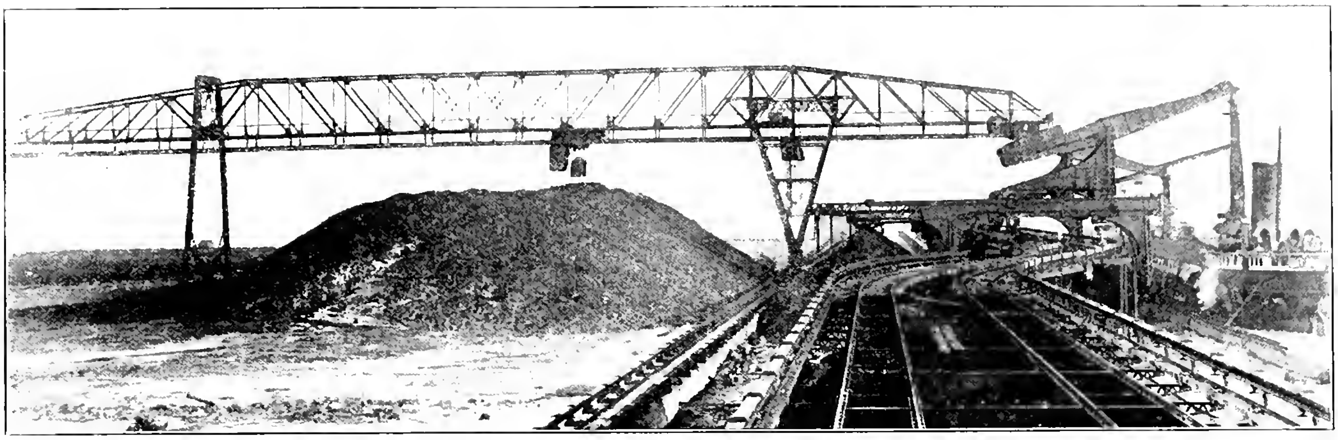


Fig. 26 Hulett Automatic Unloaders, Transfer Cars, and Stocking and Reclaiming Bridge on Canadian Pacific Dock, Fort William

preparation of coal. There is required on this bridge for its operation one man trolley operator and one oiler. This bridge has a rated capacity for unloading and stocking coal on dock from a 10,000-ton boat in 20 hours, acomplishing with a single unit and with only two men on the bridge, as much as four unloading hoists with a total of eleven units accomplished with about ten or twelve men on the equipment in the first mentioned installation (Figs. 27 and 28).

An incidental advantage of bridges long enough to span the entire width of dock is the elimination of intermediate runways or supports from the stocking area, which in the short span bridges, reduce the storage space and obstruct the operations of stocking and reclaiming.

At the present time two installations are being made, one on the Reiss No. 3 Dock at Superior, which is being equipped with a Heyl & Patterson bridge; and another on the Missabe and Northern Dock at Duluth, comprising Mead hoists and cable railway system with bridge, as previously mentioned.

METHODS OF HANDLING AT RECEIVING DOCKS

While it is evident, from a consideration of the several types of plants briefly described above, that there are several methods of handling the coal at the receiving docks, it is true that these methods group themselves under two general heads, as follows:

a That in which the bulk of coal is broken at the dock front by temporarily storing the coal in a receiving hopper, located, in the hoists, for later discharging to independent units for transferring to stock pile;

b That in which coal is delivered direct to stock pile in a single operation without breaking bulk.

Under case (*a*), where bulk is broken at the dock front, the unloading is done by fixed or traversing hoists or unloaders used only for this operation, while the stocking is done by equipment ordinarily acting independently of the hoists. This stocking equipment is of various types, and the method employed for stocking is again divided into two general classes:

(1) That in which no provision is made for longitudinal transfer of the coal, necessitating its being stocked directly back of the unloading tower, so that boat must be placed opposite the area on which coal is to be stocked.

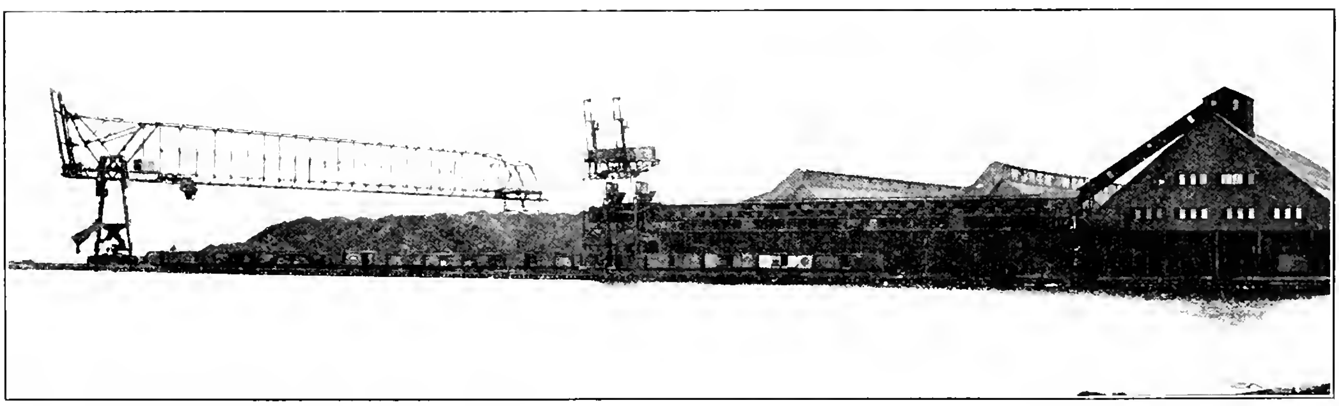


Fig. 28 North Western Fuel Company's Dock No. 1, Superior, showing Anthracite Section and Largest Coal Handling Bridge installed to Date

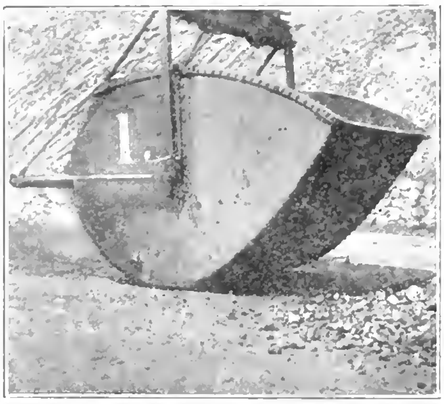


FIG. 29 BROWN 7-TON STOCKING TUB ON NORTH WESTERN FUEL COMPANY'S SUPERIOR DOCK NO. 1

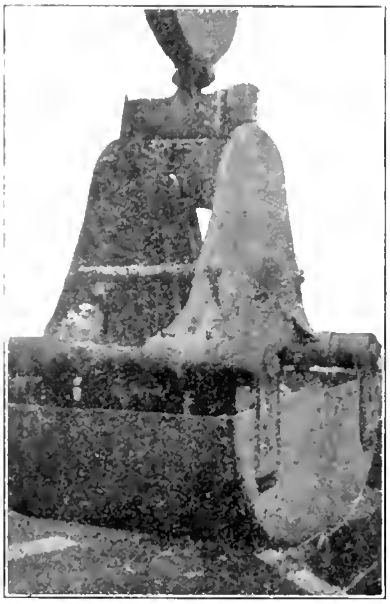


FIG. 31 FIRST RECLAIMING CLAM AT THE HEAD OF THE LAKES, DESIGNED BY FRED BARROWS. FIRST USED AT THE OHIO COAL COMPANY'S DOCK IN 1888 OR 1889

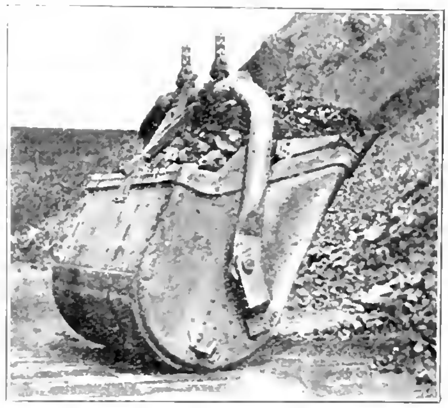


FIG. 30 BROWN 4-TON SHOVEL BUCKET ON NORTH WESTERN FUEL COMPANY'S SUPERIOR DOCK NO. 1

(2) That by which provision is made for longitudinal as well as transverse movement of the coal in transferring to stock pile, giving perfect flexibility in stocking and enabling the coal to be stocked on any part of the dock desired, regardless of the position of the boats and hoists.

Method (*a*-1) obtained in a few of the earlier plants but has now been largely, if not entirely, displaced by the method designated as *a*-2.

Method (*a*-2) is used in

Plants equipped with transfer cars and stocking bridges

Installations of dump car systems operated either by hand or by cable on bridges or stationary runways

Systems of longitudinal and transverse conveyors

Longitudinal conveyors in conjunction with trolleys, or conveyors operating on transverse runways, or bridges

Method (*b*) comprises

One or more units designated as coal handling bridges on each of which a single trolley is used for the various operations of unloading, stocking, reclaiming and delivering to bins for reshipment by rail

Traversing hoists registering with stationary runways, or combined units made up of fixed hoists in line with stationary transverse runways

Trolleys employed in stocking are ordinarily equipped either with automatic dumping tubs, which are self-righting, or with drop bottom skips.

The reclaiming of coal for reshipment by rail is done by various methods dependent in part upon the method

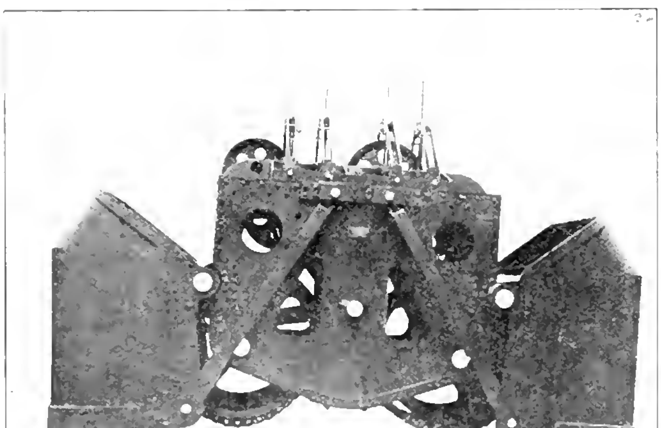


FIG. 32 HULETT $7\frac{1}{2}$-TON CLAMSHELL GRAB BUCKET

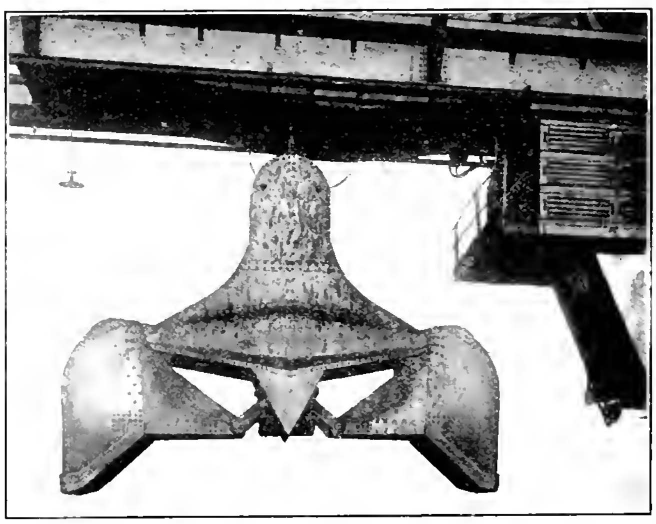


FIG. 33 HEYL AND PATTERSON MAN TROLLEY AND 12-TON UNLOADING CLAMSHELL ON NORTH WESTERN FUEL COMPANY'S NO. 5 BRIDGE

employed in stocking. Where the stocking is done by means of trolleys, automatic cars or belt conveyors, operating on bridges or runways, the reclaiming is largely done by trolleys equipped either with shovel buckets or clam-shelled grab buckets, which have practically superseded shoveling to tubs. Where coal is stocked by flight conveyors, the over and under type is used, the reclaiming being done on the lower run of conveyors, which are enclosed in concrete or timber tunnels, running underneath the coal piles.

CLAMSHELL GRAB BUCKETS

On practically all unloading equipment in which the structural and mechanical parts are of sufficient strength to permit, clamshell grab buckets have superseded the tubs formerly in common use. The clamshell, designated as the two-rope type, is ordinarily used on larger installations, while the single rope type is sometimes used in replacing tubs on old hoists, and on some new installations where simplicity of the hoisting mechanism or light weight on the trolley is desired.

The first clamshell used at the Head of the Lakes was invented by Fred Barrows, in about 1888 or 1889, and manufactured under patents of Mr. Barrows and D. B. Smith, both of the Ohio Coal Company, which patents were later purchased by the North Western Fuel Company. This clam was used for reclaiming only. A clam of this type, still in service on the North Western Fuel Company's Duluth dock, is shown on Fig. 31.

The first unloading grab bucket put into service at the Head of the Lakes, was the Newell & Ladd clamshell bucket and was installed on the Duluth dock of the Ohio Coal Company in 1895. The first clam of this type was made by the John A. Mead Manufacturing Company in 1883, and the clams were used to a limited extent in the East. This was one of the first, if not the first, clam to come into general use.

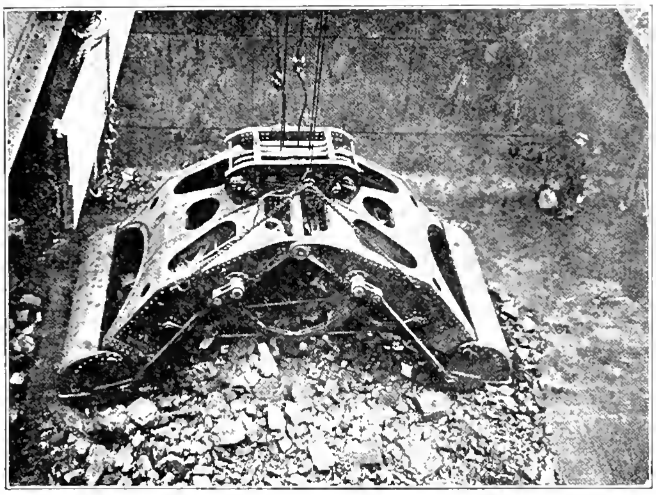


FIG. 34 HEYL AND PATTERSON 4-TON CLEAN-UP CLAM, INSTALLED ON NORTH WESTERN FUEL COMPANY'S DOCK NO. 2, IN 1912

Clamshell grab buckets of several types and makes now in use, are shown on Figs. 32 and 33.

The process of breaking down or the removal of the free coal from the hatches of the vessels at the present time, is done by means of clamshell grab buckets, which open crosswise of the boat, and are of such width as to have sufficient clearance in entering the hatch. Formerly, the coal out of ready reach of the unloading clams was either trimmed to the hatch by hand shoveling for picking up by the clams, or hand shoveled to tubs, and, in some instances, to the clam itself in cleaning up the boat. As this process, however, necessitated considerable intermittent high priced labor, various methods have been devised for cleaning up the boat by mechanical means.

The first equipment, of which the writer has knowledge, in which the cleaning up of the vessels by mechanical means was provided for, was the Hulett automatic unloader designed by Mr. G. H. Hulett, the first installation of which was made at the iron ore docks of the Pittsburgh & Conneaut Dock Company of Conneaut, Ohio, in 1898. In these unloaders, the clamshell, which is of large capacity, was rotated after entering the hatch so as to extend lengthwise of the boat, enabling it to reach the ore tributary to each hatch. These machines had an unloading capacity far in excess of any equipment previously installed, and have been extensively used in the unloading of iron ore at the lower lake ports.

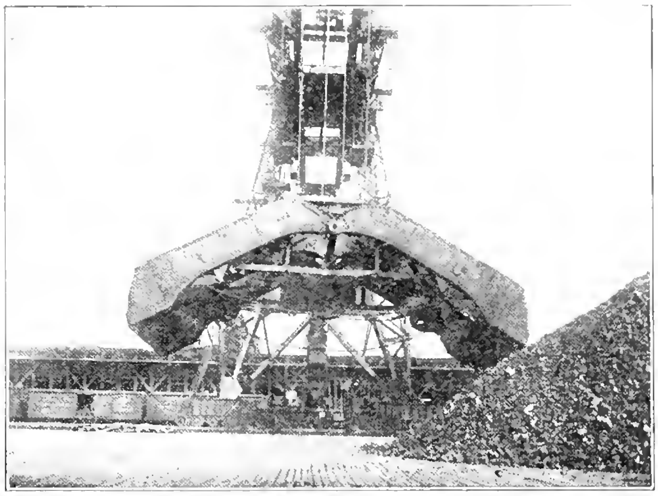


FIG. 35 HEYL AND PATTERSON 6-TON CLEAN-UP CLAM, 13 FT. 6 IN. WIDE, WITH 24 FT. REACH, INSTALLED ON NORTH WESTERN FUEL COMPANY'S NO. 5 BRIDGE, DOCK NO. 1, SUPERIOR

Following the development of the unloader above mentioned, clamshells came into general use in the unloading of both ore and coal, and several devices were tried out with varying degrees of success for scraping or trimming the ore and coal from the wings to within reach of the clamshell, with view to avoiding hand trimming and hand shoveling to tubs in cleaning up the vessels.

In the Brown swiveling trolley developed for this purpose a turntable is provided, which rotates the clam in the hold of the boat, and is used on the recent installations of the Brown equipment on the Nos. 5 and 7 docks of the Pittsburgh Coal Company at Superior and Duluth, to which reference has previously been made.

The Heyl & Patterson clean-up clam is built of dimensions to permit its entering the hatch closed and to open below deck lengthwise of the boat, with a reach of twenty-four feet, covering the entire space center to center of the hatches on each side of the hatch being worked, thus requiring the clean-up clam to be worked only in alternate hatches for boats having hatches spaced twelve foot centers. This clean-up clam, first installed on the North Western Fuel Company's Superior Dock No. 2, has been applied in a considerable number of later installations of both larger and smaller capacity, and in each case is so proportioned as to give the same total lifted load on the trolley as for the unloading bucket (Figs. 34 and 35).

The Mead Company has since produced a clean-up clam of less reach and dead weight, with capacity for proportionately greater coal load.

For the trimmings of anthracite coal within storage buildings in stocking and reclaiming, and for the transferring of bituminous screenings to and from stock piles, steel scrapers, sometimes designated as flying scrapers, were introduced in about 1890. These scrapers are ordinarily worked by means of ropes, for pulling them in opposite directions.

SCREENING

Coal is screened before shipment from the mine and all anthracite and all bituminous coal, with the exception of railroad coal, which is used largely for locomotive firing, is reprepared before reshipment from the dock, care being taken to make the coal of each grade uniform. It is also carefully inspected upon its arrival by vessel; while being unloaded; and during the process of repreparation; each car load is also inspected while being loaded for rail shipment.

Various types of screens are used, choice of type being made to suit kind of coal, the tonnage handled at a single point, and the particular part of the process for which the screen is to be used. When coal is to be loaded out through various openings in long continuous lines of bins, where the tonnage loaded out over each screen is comparatively small, single stationary lip screens are used with good results. This type of screen is also considerably used in the rescreening of the degradation made in the first screening process. For anthracite coal, the screens used are either wire mesh or perforated plate; and for bituminous coal, they are of the bar type. Automatic baffles or retarders are occasionally used for controlling the flow over lip screens, but possibly one of the most effective devices is a flight conveyor of light open construction running over the screen surface at a predetermined speed. This controls the velocity over the screen and insures uniform discharge to the car.

Where, however, large tonnage is to be loaded at central shipping pockets, either mechanical screens or a large bank of lip screens are used. Mechanical screens are of two general types, revolving screens and shaking screens. Revolving screens are provided with one full length inner jacket and one or more concentric shorter outer jackets, and shaking screens are made up either with a single bed or in tiers of two or more beds for the proper separation and distribution of the coal.

RELOADING FOR RAIL SHIPMENT

Three general methods are used in reloading coal to cars for rail shipment:

a That in which coal is loaded out through a long continuous line of bins, with loading chutes or lip screens at frequent intervals permitting the loading of several cars simultaneously. Bituminous coal, under this method of loading, was formerly trimmed in the cars by hand, while the anthracite was, and to some extent still is, trimmed in the cars by the use of telescopic chutes attached to forked aprons at the outer end of the screens. Box car loaders are now used for both kinds of coal.

b That in which the coal is loaded out through central shipping pockets, which is made possible by tilting box car loaders having capacity of from ten to twelve cars per hour or from 3000 to 4000 tons per 10-hour day.

c That in which the coal is loaded out through bins mounted on traversing coal handling bridges or through detached movable screening plants, the coal being trimmed in the car either by portable box car loaders traveling along the dock or by box car loaders mounted on the bridge or screening plant.

As a great deal of the coal is now shipped in box cars, and loading these cars by hand is both slow and expensive, a number of mechanical loaders have at various times been put on the market. The first box car loader[1] of which we have record is that invented by Richard Ramsey of Illinois in 1885. This was manufactured by the Ottumwa Box Car Loader Company and the Litchfield Foundry & Machine Company. Two years later, in 1887, William Ramsey of Iowa invented a loader which was also manufactured by the Ottumwa Company. In 1894, F. W. Bond invented the third loader, which was built by the Litchfield Foundry & Machine Company. The coal was so badly broken and the cars so badly damaged by these loaders, that their manufacture was soon discontinued.

[1] Data relative to early history of box car loaders are taken from a paper read by Wm. L. Affelder, Supt., Mosgrove Coal Co., before the Central Mining Institute of Western Pennsylvania, December 1904.

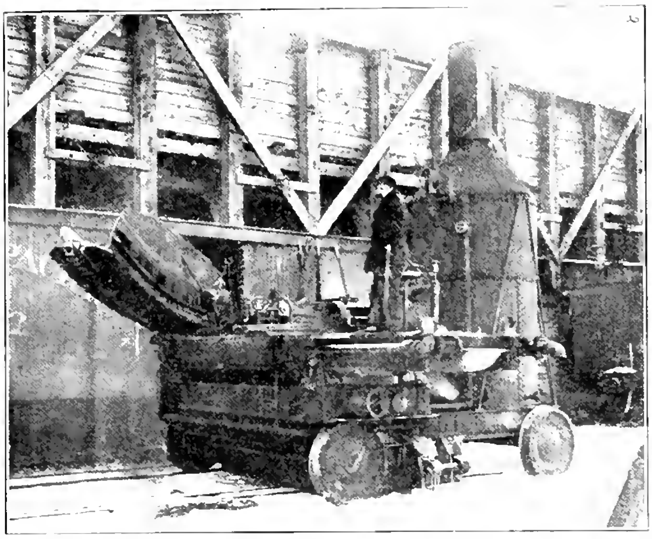


Fig. 36 Ottumwa Steam Box Car Loader, installed on North Western Fuel Company's Dock No. 1 in 1902. First Portable Loader ever built

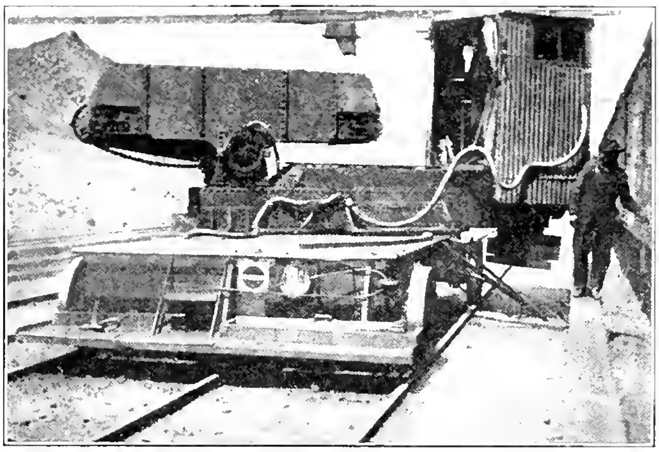


Fig. 37 Christy Box Car Loader Company's Electric Swiveling Conveyor Loader, installed on North Western Fuel Company's Dock No. 1, Superior, 1913

In 1897, the first really successful loader was manufactured by the Ottumwa Box Car Loader Company, although their first loader built two years previously was a failure. In 1898, the first Christy loader, invented by J. M. Christy, was installed in Des Moines.

The following year, the first Victor loader, invented by D. A. Chappell, President of the Victor Fuel Company, Denver, was installed.

In 1900, the Smith gravity loader, invented by S. Kedzie Smith, Civil Engineer in Billings, Mont., was installed for the Northwestern Improvement Company, Roslyn, Wash. This is manufactured by the Dodge Coal Storage Company and the Ottumwa Box Car Loader Company.

In 1902, the Ottumwa Box Car Loader Company developed, at the request of the North Western Fuel Company, and installed on their Superior Dock No. 1, the first portable box car loader. This was a steam loader, equipped with engine and boiler. The following year, the same company, also at the request of the North Western Fuel Company, developed the first electric loader, which was installed on the same dock. Since that time, a large number of electric portable loaders of this make have been installed at the head of the lakes. In the Ottumwa loader, the coal is trimmed in the cars by means of a reciprocating cradle and pusher traveling therein the full length of the cradle, Fig. 36.

During the same period, a large number of Christy portable electric loaders have also been installed on the docks in Duluth and Superior. The distinctive feature in this loader is the use of a steel lagged conveyor for trimming coal in the car, the speed of the conveyor being under control to suit conditions of loading, Fig. 37.

In 1906, a Smith tilting box car loader was installed on the North Western Fuel Company's Dock No. 1 by the Dodge Coal Storage Company, with rated capacity

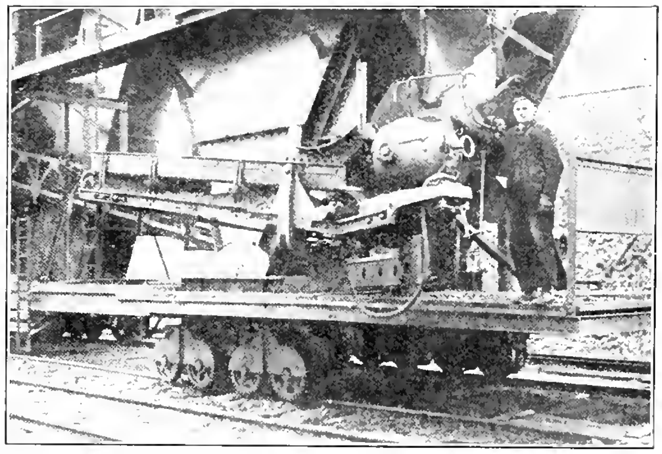


Fig. 39 Manierre Conveyor Loader, mounted on Bridge Pier, Carnegie Coal Company's Dock No. 2, Duluth

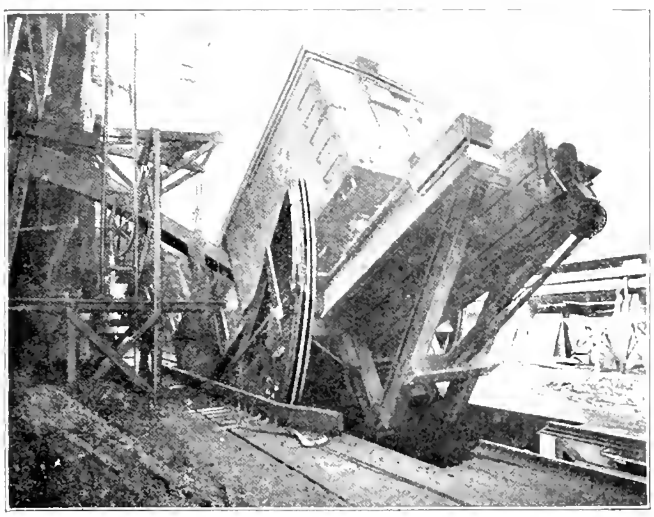


Fig. 38 Smith Tilting Box Car Loader, built by the Dodge Coal Storage Company

for handling 100 cars or 3000 tons of anthracite coal in ten hours. This loader tilts the car endwise on the cradle, which permits the flow of coal alternately to each end of the car by gravity. After the two ends are loaded the car is brought to level position and the middle of the car filled without hand trimming. This type of loader permits the loading of a large tonnage at a single central point, and is used for handling both anthracite and bituminous coal. Smith loaders have since been installed on the Philadelphia & Reading dock in Superior and the Carnegie No. 2 dock in Duluth, Fig. 38.

For the purpose of handling bituminous screenings, there was installed on the North Western Fuel Company's No. 1 dock in 1909 a Fairmont centrifugal loader, manufactured by the Fairmont Mining Machinery Company, of Fairmont, W. Va. In this loader the coal is received by a cylinder, from which it is discharged by blades attached to a rotating head.

Two other types of loaders have recently been developed in Milwaukee, one of which, the Manierre loader, is adapted for handling both bituminous and anthracite coal. The Hanna Coal Company installed two of these loaders in 1912 for handling anthracite. Since then, three loaders of this type have been installed on the bridge piers on the Pittsburgh Nos. 5 and 7 docks for handling bituminous coal, and a fourth loader for anthracite has been installed on No. 7 dock. This is a stationary type of loader, located on the same side of the car as the loading bin, as shown by Fig. 39. The distinctive feature of this loader is the swinging supporting arm, to the outer end of which the conveyor is pivoted. This permits conveyor being extended alternately into the opposite ends of the car, allowing low conveyor speed in unloading.

In 1911, the other type of stationary anthracite conveyor loader was designed by Mr. John Ecks, Chief Engineer of the Milwaukee-Western Fuel Company, and was installed on one of the docks of this company, for loading anthracite coal to box cars on two tracks, between which it is located. The distinctive feature of this loader is the reciprocating motion of the belt conveyor, permitting it to travel toward the end of the car for reducing throw of the coal to the minimum, thus permitting low conveyor speed.

The following year, one of these loaders was installed for loading anthracite coal at the North Western Fuel Company's Superior Dock No. 1.

With the exception of a few of the earlier steam loaders, the portable loaders thus far installed have been electrically operated. At the present time, however, a Christy " Superior " type loader is under construction for the North Western Fuel Company's Superior Dock No. 2, in which a gasoline engine will furnish power for the travel of the loader along the dock.

Portable loaders serve not only for loading coal, but also for the switching and spotting of loaded and empty cars.

To expedite loading operations, the spotting and local switching of cars, when not done by the portable loaders, is usually done at the receiving docks by one of the several types of rope haulage or carpuller systems. Gravity tracks are also frequently used where conditions make it desirable. At the car dumpers at the lower lake ports it is customary to run the cars down grade from the storage tracks onto a kick-back track, after which they are run onto the cradle of the car dumper by means of a small car attached to a haulage rope, variously designated as a ground hog, mule or pig.

Cars are weighed before and after loading on railroad scales of from 100 to 150 tons capacity. Both the overhead and pit types of scales are used and are ordinarily provided with dead rail. Automatic scales are used to a limited extent, and where this type of scale is not in use, the scales are of recording or registering beam type, which enables the weighmaster to retain a ticket for each car, with the net and gross weights stamped thereon, corresponding to the position of the poise, thus avoiding the possibility of error in writing the weights. The weighing in Minnesota and Wisconsin is done by the Western Railway Weighing Association. Every precaution is taken to insure accuracy in weighing, and the scales are given frequent attention and are regularly inspected by the dock companies. Periodically, inspection and tests are made by the state scale inspectors, for which purpose a special test car is used. The scales at the retail yards for weighing coal delivered by auto trucks and wagons are given the same attention. Both the track and wagon scales are balanced frequently during the day, while in service. Smithing coal, which is sacked for shipment in comparatively small quantities, is weighed on wheelbarrow scales during the process of sacking, prior to taking total weight on wagon or track scales.

Conveyor weighers, by which the weight of the coal being handled by belt conveyor is obtained automatically by electrical device, have been in use for several years to a limited extent by purchasers of coal and other bulk material, and also for check weighing, but have not thus far been used on the coal docks at the receiving ports for determining shipping weights.

CONDITIONS RELATING TO THE HANDLING OF COAL

In the handling and storage of coal, numerous precautions are necessary in order to avoid undue breakage or degradation. It is necessary to break bulk as few times as possible in handling the coal from the time it leaves the boat until it is loaded to cars for reshipment by rail. With the same end in view, it is also necessary to limit the free fall of the coal and the velocity of the flow as much as practicable. In compliance with above conditions, coal handled by clams or other buckets should be lowered to pile or bin before being discharged. An ideal device for lowering anthracite and other small sized coal vertically, where

the drop would be large, is the Humphrey type of shelf lowering chute, which consists of a vertical shaft, in which the shelves, placed alternately on opposite sides, are so arranged that the coal flows over itself at a uniform moderate velocity, regardless of the distance through which the coal is lowered. Where it is desired to lower and also convey the coal horizontally by gravity, step chutes built on similar principle are employed to advantage.

The deterioration of bituminous coal in storage is slight, and recent experiments show it to be less than it is commonly supposed to be. Anthracite coal is not subject to any appreciable deterioration even though stored out of doors, but to supply the demand for bright coal it is housed in buildings for protection from the weather.

The liability of bituminous coal, especially screenings and some grades of run of pile, to spontaneous combustion, has made it necessary to limit the height of pile to suit the available rehandling facilities, as the first step in handling a coal fire is to get direct access to the fire by rehandling the hundreds, and frequently thousands, of tons of coal within the inverted cone tributary to the small area at the bottom of the pile, where the fire starts. It is sometimes also necessary to isolate the burning area to prevent the fire spreading. After the fire is uncovered, it can be extinguished by the use of water and the rehandling of the smoldering or burning coal. The application of water, however, to the top of the original coal pile is ordinarily useless and frequently increases the fire. While the liability to spontaneous combustion cannot be entirely eliminated, a clean dock surface and the absence of combustible foreign matter within the coal pile, and, after the coal is in storage, careful watching and prompt rehandling upon the first indication of heating, reduce the liability to a minimum.

Another essential condition, which is being complied with in an increasing degree, is the safeguarding of employees by the provision of sanitary conditions

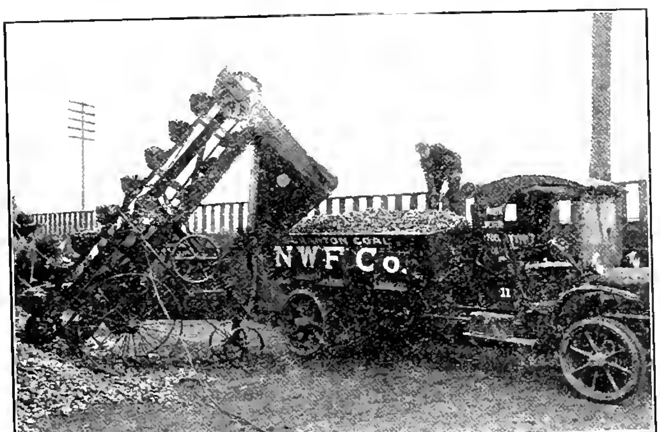


Fig. 40 Specialty Engineering Company's Wagon Loader, North Western Fuel Company's Yard No. 1, St. Paul, 1914

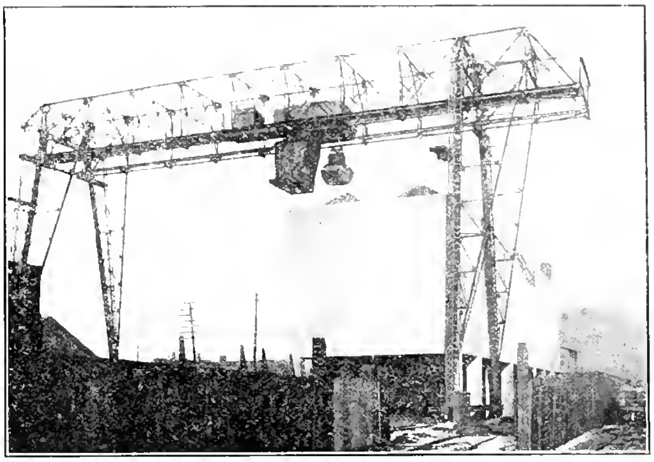


Fig. 41 McMyler Mechanical Plant for Retail Yard Cleveland and Pittsburgh Coal Company's Retail Yard, Cleveland

and the application of safety appliances to the dock equipment. For the removal of coal dust from enclosures where it is produced in unusual quantities, dust exhaust fans are being introduced for the benefit of employees and to facilitate operations.

The use of electric power in place of steam, which was common until twelve or thirteen years ago, has several very marked advantages. Electric power can easily be distributed, with comparatively small loss, to various remote centers on movable equipment. Branch lines can readily be cut out when not in service, and there is slight loss from leakage in feeders whether the motors are in operation or idle. Other advantages are the control of motors by means of magnetic switches and master controllers, and the ease with which automatic safety devices can be introduced for safeguarding operations of hoisting and lowering of bucket, and traversing of man trolleys and bridges. Dynamic braking is also a valuable feature in man trolley operation, where the loads are heavy and high speed is attained. Probably the greatest disadvantage in the use of electricity in place of steam is the absence of steam for heating purposes, as, while the use of electric heaters is feasible, the cost is excessive. In hoisting operations, current fluctuations are excessive, owing to peaks incident to accelerating and to intermittent operation of the individual units. When conditions warrant, provision is made for equalizing the load on the generating plant by the installation of motor-generator flywheel set or storage battery.

The handling of coal in retail yards is another important branch of industry. The most of these yards simply have covered sheds, into which coal is unloaded from cars and from which coal is loaded into wagons and auto trucks by hand shoveling. Where the volume of business warrants, however, elevator and conveyor installations for unloading and stocking coal in sheds and bins are coming into more general use, and electric portable wagon loaders, shown on Fig. 40

for taking coal from storage pile at ground level and loading to delivery trucks are being more generally used. An increasing number of plants are being installed for mechanically performing all the operations at retail yards of large capacity, with three to five ton auto trucks for long hauls, Fig. 41.

The non-occurrence of high grade coals in this section of the country, and the high cost of delivery by rail incident to long haul, make of vital importance careful consideration of the subject of cheap lake transportation, and the development of mechanical equipment which will at low cost, and with dispatch, load, unload, and deliver to the consumer the large and rapidly increasing tonnage of coal required for distribution throughout the northwest.

The writer wishes to acknowledge the courtesy, which has been extended in furnishing information for this article by the management of the various coal companies and by the manufacturers of the equipment herein described.

MINNEAPOLIS FLOUR MILLING

BY CHAS. A. LANG, MINNEAPOLIS, MINN.

Junior Member of the Society

IN the popular mind, the word flour is as intimately associated with the name Minneapolis as steel is with Pittsburgh. The first manufacturing enterprise in Minneapolis was a government grist mill built in 1823 by Colonel Snelling from whom Fort Snelling derives its name. He sent, under Lieutenant McCabe, a detachment of fifteen soldiers to the west bank of the Falls of St. Anthony and on the site of the present mill "D" of the Northwestern Consolidated Milling Company, the first mill was built. It was a crude affair about 20 ft. square, built of logs and containing one pair of mill stones. The power was derived from a log flume from the crest of the Falls, discharging into a flutter wheel at the mill.

From such a beginning has the present milling industry and its allied interests grown. The potential possibilities of the Northwestern territories for the production of wheat was, at that time, undreamed of. The water power was evident and gave the first incentive for the building of grist mills and lumber mills at Minneapolis. The supply of wheat in that time was the most serious handicap. The fitness of the soil in the immediate vicinity for raising wheat was not known. The soldiers at the time of building the first mill tried their hands at raising wheat and as very light crops resulted, they were soon discouraged and gave it up. This first mill ceased grinding wheat about four years after being built.

This seemed to be the end of flour milling, for nothing was heard of the government mill until about 1849 when the town of St. Anthony was established on the east side of the Falls. The first court ever held in Hennepin County convened in the old mill in 1849. The mill was apparently the only place available at that time for court sittings. It is a far cry from a grist mill to a court of law, and serves to show how close was the connection of the flour mill with the early history of the settlements which were to form the future city of Minneapolis. The west side of the river at the Falls was still a government reservation. Upon this ground now stands what is known as the milling district and is the center of the flour manufacturing industry in Minneapolis.

The history of the various mills as they were developed from the time of the old government mill is too long a story to go into at this time, covering as it does, a period of some 80 years. This history in itself covers practically every development and invention that gave rise to the present system of American milling. It is not a record of success in every venture, for mills were destroyed by flood and fire and rebuilt in continuously increasing size and completeness. Some men made fortunes and others failed. With them all there was the belief that Minneapolis would be a great milling center. Transportation facilities were crude and uncertain; the difficulties of getting the grain to their mills and their product to the markets of the world made many give up the field. Mills were dismantled, built and rebuilt to take advantage of some newly invented system of milling, and money was spent with a lavish hand to improve the quality of their product over that of their competitors. It became a question of the survival of the fittest. One mill would receive a shipment of machinery and try to hide the fact from the other mills. The mill would be closely guarded while this new machinery was installed and operated. It would be but a short time before one of the employees would go to some other mill and the secret become common property. There is no doubt but that this keen rivalry between the various mills in raising the standard of the product of all the mills, gave Minneapolis its standing to the point where Minneapolis Patent Flour is the standard by which all are judged.

The great mill explosion of May 2, 1878, which destroyed the Washburn "A," Pettit, Galaxy, Humboldt, Diamond and Zenith Mills, threatened to bring Minneapolis milling to a sudden end. Instead of that,

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the industry was many times strengthened by new and better mills erected on the site of the ruins. In the new mills, the mistakes of the past were corrected and the possibility of a second dust explosion greatly lessened by the use of air suction systems for removing the dust as it was created in the machines and before it could fill the air of the mill. This great explosion occurred in the Washburn "A," and was so violent that it is said that hardly one stone was left on top of another. The walls of the surrounding mills were wrecked so that the fire, which followed, quickly completed their ruin. A second fire occurred in 1881, which destroyed the Pillsbury "B," Excelsior, Empire and Minneapolis Mills, the latter exploding as a result of the fire. The rebuilding of these mills marked the passing of the old milling district.

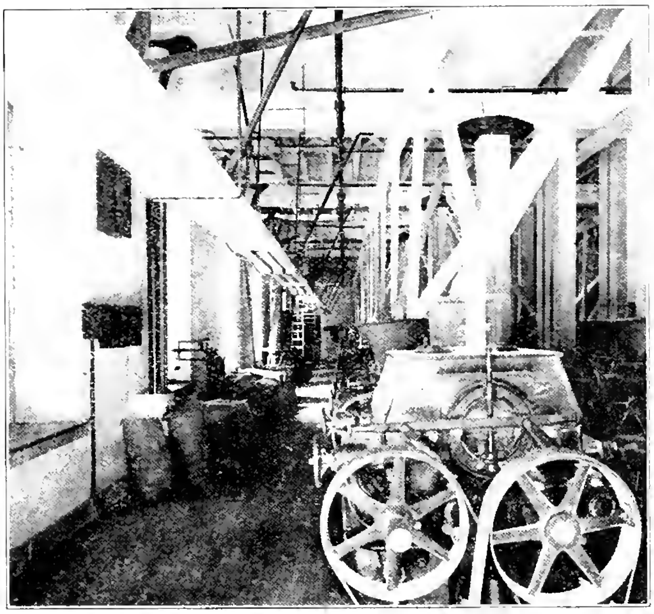


Fig. 1 Roll Floor

From that time up to the present, the operations have been more in the increasing of capacity and the improving of milling systems than in the building of new plants. The larger companies have improved their grain handling facilities by the building of large terminal elevators in connection with their mills. This grain storage assures a uniform supply of the various grades of wheat and puts it in the proper condition for delivery to the mill. The building of these elevators as well as the increase of capacity of the mills, called for increased power. To meet this condition large central steam power stations have been built and hydraulic turbines of increased power and efficiency installed, so that in the present milling district is seen some of the most modern and up to date power apparatus that the market affords. As an example, at the present writing, there is being installed by two milling companies, two pairs of 42-in. hydraulic turbines of 1800-h.p. capacity, to have in their settings a guaranteed efficiency of 87 per cent. All of the larger mills have their water power supplemented by steam power or electric motors driven from the central steam stations. Where formerly each mill had its individual

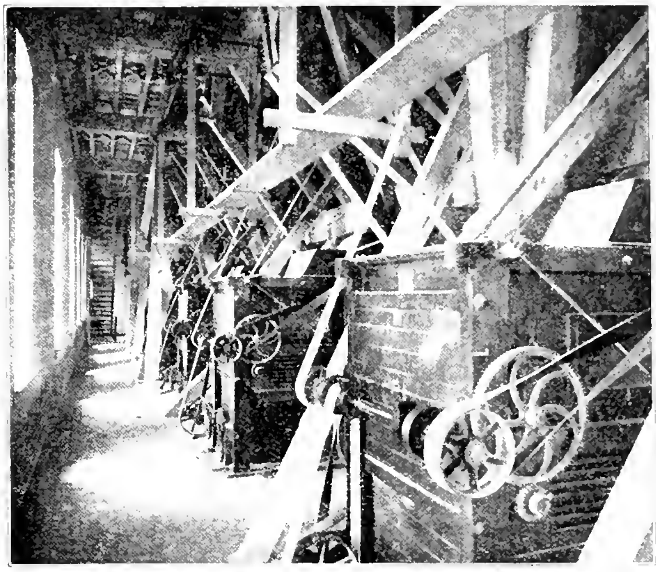


Fig. 2 Purifier Floor

steam plant for relay, most of these have been abandoned in favor of the electric drive from central stations. The consolidation of the various mills into the present three large companies made it possible for each to centralize its power.

The present capacity of the Minneapolis mills is 84,000 bbl. of flour every 24 hours. There are 23 mills,

Fig. 3 Sifter Floor

which makes the average capacity 3600 bbl. per mill. The largest mill in the world, the Pillsbury "A," has a record of having made 16,125 bbl. in one day, although its capacity is rated at about 11,000 bbl. The

mills vary in size from this to experimental mills of a few hundred barrels capacity. Flour mills run 24 hours a day, sometimes for many weeks without stopping. The usual running time is from Monday morning to the following Sunday morning.

THE MINNEAPOLIS WATER POWER

The Falls of the St. Anthony have played so prominent a part in the development of milling in Minneapolis, that they deserve special mention. The present developed power is approximately 60,000 h.p. under an average fall of 47 ft. This power, with the exception of 12,000 h.p. in the Hennepin Island station used by the Street Railway Company, is practically all taken by the flour mills. The races from the mills and this island station discharge into the pond of what is called the Lower Dam. This gives another fall of 18 ft. and is used entirely in a second plant where 10,000 h.p. is generated for use of the Street Railway Company. The Hennepin Island Station is an excess plant and is run only when the demands of all other users of power are satisfied.

The unit of measurement is the mill power defined as 30 cu. ft. per second under a fall of 22 ft., or approximately 75-h.p. gross. The mill powers are numbered from 1 to 48, there being in many cases several having the same number. Under conditions of limited water supply such as occur in the winter months, the mill powers are cut off in the inverse order of their priority number. This is, Series No. 48 would be taken off first and so on down until a balance was reached between the available supply and the amount used. It is under such conditions that the steam relays have to be used. Early in the history of the mills, these mill powers were owned or leased by the various mill owners in proportion to the power they used, and the water power company was something in the nature of a coöperative organization. The rental of the early powers was but nominal, which gave so little for dividends that free powers were given instead. These free powers and also the leased powers are perpetual and non-assessable. As the value of the power began to be appreciated, the rental increased when new leases were made to where $1000 per year was charged for Series No. 48.

In the water power development of the main falls, there is nothing that could rightly be called a dam. Underlying both sides of the river and the falls, is a limestone ledge which is about 12 ft. thick on the downstream edge, and which tapers in thickness as it extends up stream to where it stops some 1200 ft. above the Falls. In fact, it is like a shingle with its thin edge lying up stream. The downstream edge of the ledge is in the form of a great hollow square or horseshoe whose sides extend down stream. At the upper end of the hollow square in the center, is the spillway. This is an apron which protects the face of the ledge and slopes from the top of the ledge to the pool below. Starting from either end of the apron, extending up stream and built on top of the ledge in an elongated U shape, is a dam which gives a depth of water of 14 ft. above the ledge, forming the mill pond, from which the water is taken in canals to the mills. The water spills over this dam on to the ledge and down over the apron. From ends of the apron and forming a continuation of the dam, are walls built on top of and following the edges of the ledge downstream. These walls form the river side of the main head races to the mills, one on either side of the river. The mills on the river side of the head race have their front walls built on the wall of the canal and their back walls extending down to tail race level, making them some three stories higher in the back than in the front. These mills take their water supply through penstocks and the water-wheels discharge directly into the main tail race. The mills on the other side of the head race take their water through canals from the head race into open flume waterwheel settings. These wheels discharge through holes cut through the ledge. From these wheel pits tunnels are cut under the ledge to the main tail race. The formation below the ledge is a tightly compressed white sand which just misses being sandstone, and it is through this that the tail races are cut. Most of these races are lined with concrete or brick up to the ledge, the ledge making the roof.

The water power development in its present state was not reached without as many serious mishaps as befell the mills in their evolution. The earlier retaining walls and canals were timber and crib structures, and there were many wash-outs, even carrying entire mills away. In 1870 the most severe wash-out occurred. Through a break on the east side, almost the entire river ran under the ledge, and it looked as if the Minneapolis water power were a thing of the past. It was then that the federal authorities were called upon for help. Congress appropriated over half a million dollars, and with this a dike or cut-off wall was built across the river under the ledge.

In the early days there was no attempt made to maintain a uniform head of water by limiting the amount each mill could use. When the water was low it was just a grand scramble to see who would get enough to keep their mill running. Stories are told of how, when there would be but two or three feet of water in the canal, the crew in one mill would build dikes of sand bags and boards to divert the water into their wheel pit. Then the crew from the mill below them would try to tear out the dike so they could get the water, and a fight would ensue with material damage to the heads of the party having the smallest number of picks and shovels. The power on the east side of the river was controlled by the St. Anthony Falls Water Power Company, and on the west side by the Minneapolis

Mill Company. While these two companies still exist, they are now under the same management.

THE MILLING PROCESS

Probably the oldest known mechanical process is the reduction of seeds or grain to meal. The prehistoric man may have had a loom for weaving his cloth, but he did not leave one for us to see. He did leave us the hollowed out boulder to testify to the fact that he ground his wild seeds that they might be made more suitable as food for human beings. He discovered the fact that his digestive apparatus was not effective in penetrating the outer protective coating of the seeds so that the meat within might be assimilated and give him strength. His mental processes may have been as crude as his time, but they were concerned chiefly in getting food and clothing—mostly food—and he seems to have solved the problem for many following generations.

For centuries the mortar and pestle were the mills for the grinding of grain. It is still used in the less civilized countries. Then came the stones which were too large to be easily used by hand and were turned by animal or man power in treadmill style with a long sweep attached to the upper stone. The French Buhr stone of the present day is the same idea except that the upper stone is driven by a vertical shaft which passes down through the hole or eye of the lower or stationary stone. This type of mill is not entirely obsolete but is used in some of the present day mills for finishing certain of the purified streams or middlings.

In 1839 came the next step when cast-iron rollers began to be used in Budapest. The first successful machine used there was the Sulzberger cast-iron roller machine. About this same time the Hungarian millers began to use the gradual reduction process which came to be known as the Hungarian process. The term Hungarian process is misused when it is given to cover the use of chilled iron rolls, and such is often the case. This process can be carried out on Buhr stones as well as on rolls.

The next improvement was the purifier which was developed in Minneapolis, and is distinctively an American contribution to milling, although some attempts had been made in France to use such a machine. The purifier is a machine which in simple terms can be described as a reciprocating sieve over which passes certain of the streams of mill stock and through which is drawn a current of air which removes the dust that would cause discoloration in the finished flour.

The old-time method of making flour was to reduce the wheat berry in one grinding operation to as nearly the fineness of the finished product as was possible. That part of the bran or husk which was not at the same time reduced to an equal fineness to the flour, was removed by sifting. The flour obtained by such a process was inferior in color, containing as it did a large percentage of finely ground bran and dust from the crease in the wheat berry.

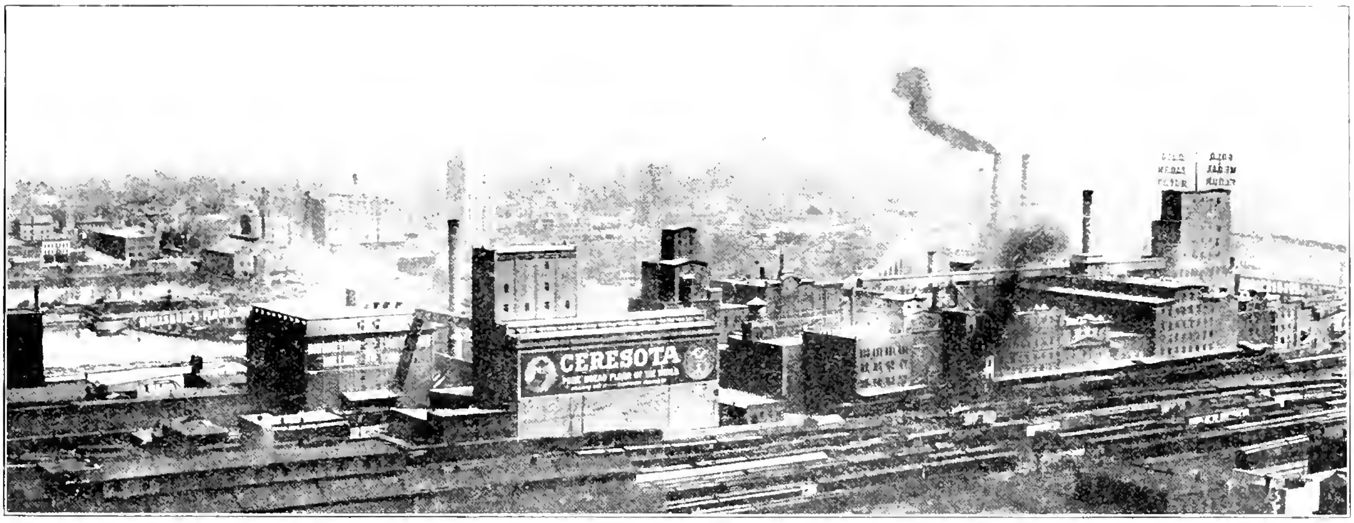


Fig. 4 Milling District from West

The Hungarian, or gradual reduction process, is the system in which the wheat passes through numerous grinding operations in series before its final reduction to flour. The first grinding operation, or first break, as it is called, lays the berry open. The next or second break, cuts off some of the inside of the berry left exposed by the first break. The third break takes off some more, and so on to the fifth and final break where nothing but the bran is left in its familiar flattened condition. The pieces of the inside of the berry cut off by the break rolls, are called middlings and are what are finally reduced to flour. The middlings are passed over the purifiers and the dust caused by the grinding is removed. Dust cannot be removed from the flour, and therein lies the advantage of the gradual reduction process in producing clean,

white flour. The term cut is used in describing the action of the break rolls, as these rolls have knife-like corrugations on their surfaces, and actually do cut rather than grind.

The color of finished flour, aside from its being free from impurities, is obtained by granulation. A piece of glass reduced to powder is pure white. This is because the light which it reflects is broken up by the facets of the minute particles. So it is with flour. The inside of the hard spring wheat berry is an opaque, flint-like substance, slightly yellow in color. When reduced to the fineness of flour, the more granular or sharp the particles, the whiter the color.

FIG. 5 MILLING DISTRICT AND FALLS FROM EAST

The wheat from the different sections of the country tributary to any mill is by no means the same in characteristics or quality. Again the wheat grown on a certain piece of land this year, will in its milling value or strength, be very different from that grown last year, even though the same seed be used. The quality of the wheat is a variable but the quality of the flour must be a constant. The color of the flour must be the same this year as it was last year; the gluten must be of a certain percentage and quality, and its ability to absorb water must not vary. The modern mill has a well-equipped laboratory, and it is here that the various kinds of wheat are tested as to their value for making flour. A large part of the available supply of wheat may be inferior in color or low in gluten. A stronger wheat must be found to blend with it, that the product may be uniform.

The various kinds of wheat are delivered to the mill elevator loaded in bulk in box cars. These cars may come from the large terminal grain storage elevators or directly from the small farmers' elevators that are scattered along the lines of railroads that tap the wheat producing country. The wheat is taken out of the car by power shovels and drops through a grating into a receiving hopper. From here it is elevated to the top floor of the elevator and discharged into a garner which is large enough to hold the contents of the largest car, or about 2,000 bu. The garner opens into the hopper of the receiving scale, and the car load is weighed in one draft. The wheat then falls into what is called a receiving separator which is a machine having a number of reciprocating sieves of perforated metal. This removes the coarse refuse such as pieces of wood, coal, iron ore, straw joints and even an occasional Ingersoll watch. It is then ready for storage and drops on conveyor belts which discharge directly into the storage bins. This wheat having been inspected and graded before unloading, is carded to go to bin No. 20, for instance. Bin No. 20 contains wheat of the same grade or of the same value for milling purposes. The advantage of a large mill elevator lies in this ability to take care of many kinds of wheat and store them in quantities that insure a uniform mixture.

In the basement under the storage bins is a conveyor belt having spouts leading to it from the bins. By means of graduated slides in these spouts, a predetermined percentage of wheat from any bin may be drawn on to the conveyor. A number of bins may be drawn upon in this manner to get a wheat mixture that is right for milling. The mixing conveyor discharges into an elevator which takes the wheat again to the top of the elevator where it passes through another weighing process on its way to the bins in the mill proper.

This wheat is still far from being in condition for grinding. Every bushel contains from one to two pounds of foreign seeds, such as oats, cockle, mustard, grass, flax, etc. These are removed by passing over numerous sieves in the milling separators. These seeds, after the removal of the mustard, are pulverized and sold as stock food or ground screenings.

The next step is the cleaning process. There are two different methods in use, the wet and the dry. In the wet process the wheat, together with a stream of water, passes into a washing machine, or "whizzer." This machine has a rapidly revolving cylinder which violently agitates the wheat in the flowing water. As the wheat passes further along in the machine, the water, together with the impurities, is thrown off by the centrifugal force, partially drying the grain at the same time. The wheat has to be dried further by dropping through large cylinders having baffles to retard the flow, while hot, dry air is blown upward through the cylinder, thus completing the drying. The dry process cleans the wheat by dry scouring many times in series. The scouring machines used have cylinders made up of chilled iron plates having very narrow openings or vents. Inside of the cylinders are rapidly revolving paddles or beaters that keep throwing the wheat against the cylinder. At the same time a strong current of air is drawn out through the

vents in the cylinder, which removes the dust and material that is scoured off the wheat. Each machine gives nine separate scourings and four or five machines are used in series. This scouring is so complete that the outer coating of the bran and the " beard " of the wheat is removed, yet the berry is not broken or bruised, but emerges in a smooth, polished condition.

After having had so much air drawn through the wheat, the shell or bran has become dried out and is so brittle that if put over rolls in this condition, this bran would pulverize and become impossible of separation from the flour. To correct this, the wheat is dampened, after which it is allowed to stand for a number of hours in a bin, that the moisture may penetrate the bran. After coming from the bin, the stream of wheat is passed through live steam which still further toughens the bran by driving the moisture in. This is called the tempering process.

The tempered wheat is now ready for grinding and flows directly to the first break rolls where the berry is opened up. The stock then passes to the scalping process, which is the separation of what flour and middlings are made by the first grinding from the bran, which has practically all of the inside of the wheat berry adhering to it. The scalping is done on revolving cylinders of wire cloth called reels, or on large gyrating sifters having a number of flat sieves of wire cloth. As small an amount of flour is made on the first break as possible, as this flour, containing as it does some of the dust from the crease in the wheat berry, which cannot be removed by any washing or scouring process, is inferior in color and must be diverted to the lower grade products. This applies to practically all of the flour made on the break rolls.

The first break stock after scalping, passes to the second break rolls. It is on these rolls that a large amount of middlings are made. This stock is treated to remove the middlings and flour in the same manner as that from the first break, after which it passes to the third break. The process is continued to the fourth and fifth breaks when all of the inside of the berry has been removed from the bran. The bran then goes to a machine called a bran duster which removes what flour has adhered to it. The bran duster is somewhat on the same principle as the wheat scourer, except that soft brushes are used instead of paddles or beaters, and the cylinder agaiinst which the bran is brushed, is of wire screen. This finishes the bran so far as the milling process is concerned and it is ready to pack out.

The middlings made by the break rolls vary in size from that of a coarse quartz sand to a fineness that is hardly different from that of finished flour. These middlings are graded or sifted into six different sizes, so that each resulting stream contains granular particles of practically the same size. This sifting is done through wire or silk gauze having very accurately spaced meshes. These streams of graded middlings then pass to purifiers where strong air currents are drawn upward through them as they pass over the sieves, the meshes of which are of a spacing that does not permit of the granular particles falling through. The coarser middlings then pass to reducing rolls having finer teeth or corrugations than the break rolls, these corrugations being still finer for the smaller sized middlings. The action of the reducing rolls is still a cutting action, it being the idea to make finer middlings of coarser, and not to make flour in the process. From these rolls the grading and purifying process, followed by further roll reduction, is continued until all the streams of middlings have been reduced to very nearly the fineness of flour.

The final reduction of middlings to flour is on smooth rolls where the action is more truly a grinding one. The stock passing to these rolls is so very fine grained that this action extends still further the granulation process and instead of flattening or rounding up the particles, the flour obtained is sharp and granular. Not all of the middlings are reduced by the first passage through the smooth rolls to the proper fineness for flour, so the stream must pass again to a reel where the finished flour sifts through the silk cloth covering and the middlings that are separated out, sent again to the smooth rolls for reduction. This process is continued until all the stock is dressed or sifted to flour. From wheat to flour there are about 21 reductions in the process.

The second grade of flour made in the process is called " bakers " or first clear. This is composed of the cleaner flour from the break rolls and part of the flour made in the reduction of the middlings, including that taken out of the middlings by the air purifying process. This flour is not as white as the First Patent and while high in its percentage of gluten, this gluten does not have the expansive power of that in the Patent Flour. The expansion of the gluten is what makes large, firm loaves of bread, while its quality determines the lightness of the loaf and to a certain extent, its color.

The next lower grade of flour is the Second Clear, and is made up of all the rest of the by-product flour that is " clear " of fine particles of bran. Every machine in a mill, roller mills, bolters, purifiers, reels and elevators, has an air suction connected to it. This suction system yields a large part of the lower grade by-product flour.

The next product is known as " Red Dog " and consists of that part of the flour which contains very small particles of bran that cannot be separated from it. It is the dividing line in the mill products, being a mixture of flour and bran.

Then comes the " Shorts " which consists of finely divided particles of bran. While it is the idea in milling to keep the bran intact, there are many small par-

ticles broken off in the process. The ones that are large enough to be sifted out, go to shorts.

A great many adjustments in milling machinery are provided for. Slides and valves in the spouting enable various streams of mill stocks to be combined or divided at will, or switched from one machine to another. There is a continual changing of the flow of a mill that the flour may be uniform. On a damp, rainy day, the flour absorbs moisture and does not bolt or sift through the silk cloths as freely as on a clear, dry day. At least once an hour, the flour is tested by wetting a sample and comparing with a standard sample which is of unvarying quality. The wetting emphasizes any tendency to change in color. It may be that the test shows that some of the stock going to the First Patent should be diverted to the second grade or Bakers, and a change in the flow is made accordingly. If the stock bolts too freely, the flour will be too coarse. A reel having a light load bolts more freely than one having a larger stream passing through, and the tendency to coarseness in the flour must be corrected by shifting a larger stream to the lightly loaded reel. Aside from these tests made in the mills, the mill laboratory plays an important part in keeping the product uniform. In companies having several mills, samples are taken every day of the run of each mill and baked into test loaves of bread. The millers from the various mills come together at bake room time and judge the bread according to size of loaf, texture and color. This keeps the flour from each mill in the group the same as that from the others. At the same time are seen samples of the gluten with its percentage, samples of dough which is another guide to color and test for moisture in the various mill products. Tests for ash which give the mineral salts content are made in retorts. This is another indication of the strength of the wheat and expansion of the gluten. In fact every possible test is made that leads to a complete knowledge of wheat and mill products. Modern American milling in its highest development is a scientific process and not guess work as was the older process. Absolute uniformity of product is assured whether made in one mill or several.

It may not be out of place to give some idea of the power necessary to drive a flour mill. With 1000 h.p. the average modern mill will make 2500 bbl. of flour per 24 hours. This gives a power consumption of a little less than 10 h.p.-hr. per bbl. Taking 1000 h.p. as a basis, there is one mill in this country that makes 3500 to 4000 bbl. or a power consumption of 6 h.p.-hr. per bbl. Another mill makes 1200 bbl. with the same power. These two mills may be called the extremes. The first mill has power transmission machinery that cannot be excelled by any manufacturing plant, and the mill building is of steel and concrete which assures perfect alignment of shafting. The second mill is a freak in that it has two or more times the amount of milling machinery than another mill of the same capacity would have. As the friction load is 38 to 40 per cent of the total, perfection in the transmission machinery or the amount of mill machinery are, very largely, the deciding factors in the power efficiency of the mill.

In the average mill, the distribution of power to the various classes of machinery is as follows:

	Per Cent.
Wheat cleaning	35
Smooth rolls	25
Breaking and middling rolls	14
Bolting, purifying, etc	26
	100

This includes the transmission and friction losses including that of the machines themselves.

Flour mills, in general, are driven as a unit from a single source of power. The process from start to finish is a continuous one, and the various streams must not be stopped. If troubles occur through breakage of machinery the entire mill must shut down, else the choking up of spouting and machines would cause more delay than the accident itself. There are a few mills having group drive by motors where the roll floor is driven by one motor, the bolting machinery by another, etc. With such a drive, remote push button control is necessary to stop and start all motors at the same instant to prevent choking. Aside from this an interlocking system on the trip and no voltage release coils should be used, so that if one motor were cut out by an overload or no voltage, all the motors would be released at the same time. The advantage of such a system over unit control is doubtful. The grain-machinery in the storage elevator and the flour packing machinery is very often used with individual drive.

A flour mill offers almost ideal conditions for cheap production of power. The load is uniform and steady, so that the load factor is practically unity.

The writer is indebted to the Northwestern Miller for facts relating to the history of milling in Minneapolis.

REPORTS OF MEETINGS

MILWAUKEE MEETING, MARCH 21

The second joint meeting of the technical societies of Wisconsin was held in Milwaukee on March 21, 1914, with a very large attendance, about 500 being present at the morning session and 700 during the afternoon and evening. Wm. George Bruce, secretary of the Merchants and Manufacturers Association of Milwaukee, delivered the opening address. Alfred O. Crozier presented a paper on Cement and Clay Products Contrasted. He was followed by Prof. R. C. Disque, who spoke of the Historical Significance of the 1907 Wisconsin Law for the Regulation of Public Utilities, which was the first significant attempt to treat the problem of legislative regulation as a two-sided question. Professor Disque traced the history of such regulation and described in detail the various points of the law passed.

Dinner was served at noon, A. A. Gray addressing those present. At the afternoon session, papers were presented on Principles of Illumination, by John Hayes Smith; Principles of Street Lighting, illustrated by slides, by Arthur J. Sweet and Francis A. Vaughn; Manufacture of Pure Iron Products, illustrated by slides, by G. F. Ahlbrandt; the Measurement of Gases in Large Quantities, illustrated by slides, by J. C. Wilson; Modern Machine Tools, by A. Wood of Lodge & Shipley; and Development in American Power Plant Machinery, illustrated by slides, by Prof. A. G. Christie.

Following a supper a lecture on Radium was given by Dr. Herbert N. McCoy, which was illustrated by lantern slides.

ST. LOUIS MEETING, JUNE 3

The June meeting of the Affiliated Engineering Societies of St. Louis was held on the 3d under the auspices of the Society. H. R. Setz gave an informal talk on Oil Engines, with special reference to the Fulton-Tosi Oil Engine, in which he discussed the principal engineering problems involved in Diesel engine construction. Mr. Setz restricted himself to the moderate speed vertical four-cycle engine as the type which, by virtue of its unsurpassed reliability in continuous operation, is leading all others. The vast experience obtained with this prime mover in thousands of installations gradually evolved typical constructive elements, which in their main parts were analyzed and explained by lantern slides. Mr. Setz further showed how American conditions could be successfully met without impairing economy or reliability of operation. The economic side of the Diesel engine was touched upon and data produced to show its great possibilities in this country, particularly in the South and Southwest.

CINCINNATI MEETING, JUNE 4

A joint meeting of the Cincinnati Section and the Engineers Club of Cincinnati was held on June 4 at the University of Cincinnati. W. A. Phillis of the National Tube Company, Pittsburgh, spoke on the subject, From Ore to National Pipe. The address was illustrated with motion pictures and Mr. Phillis showed his audience many interesting phases of the manufacture of pipe, such as the mining of the ore, the transportation of the ore to the lakes, the handling of the ore at the docks, the loading of the ore transports, the making of pig-iron at the blast furnaces, the open-hearth and bessemer processes of making steel, the pouring and handling of ingots, the rolling of the ingots into slabs, and the rolling, welding, inspection and handling of pipe.

NECROLOGY

EMIL C. BOERNER

Emil C. Boerner, consulting mechanical engineer for Russell, Burdsall & Ward Bolt and Nut Company, died in Port Chester, N. Y., on May 27, 1914, after an illness of some months duration.

Mr. Boerner was born in Germany on May 23, 1843, and came to the United States at the age of fifteen. His first connection was as an apprentice to Russell, Burdsall & Ward, and at the time of his death he had served the company for fifty years. When he first entered their employ their only plant was situated at Pemberwick and was operated on comparatively small lines. After a number of years spent in the upper shop, he severed his connection to go into partnership with George C. Mertz in the wood planing business. Upon the dissolution of this firm, Mr. Boerner went to Providence, R. I., as a machinist, but after a brief time returned to Port Chester to his early employers.

Mr. Boerner was a designer of automatic bolt and nut machinery.

FRANK L. BUSEY

Frank L. Busey was born in Urbana, Ill., on August 28, 1872, and was graduated from the University of Illinois in 1895 with the degree of B.S., receiving also the degree of M.E. in 1898. He was employed in various engineering capacities in Chicago from 1895 to 1900, and in 1905 removed to Seattle, Wash., to enter the office of a consulting engineer. He returned to Urbana in 1906 as first assistant in the engineering experiment station of the University, resigning in 1911 to become assistant chief engineer for the Buffalo Forge Company, Buffalo, N. Y., which position he held at the time of his death.

Mr. Busey was a frequent contributor to the engineering magazines, writing for the most part on his special subjects of heating and ventilating. He had just completed a handbook on fan system apparatus, under the direction of Willis H. Carrier, which was in the printer's hands when his death occurred at the Battle Creek Sanitarium on June 7, 1914.

GEORGE A. DOUGHTY

George A. Doughty, who died on March 8, 1914, was born in Brooklyn, N. Y., on April 2, 1878, and was educated in the public schools, Brooklyn Polytechnic Institute, and Stevens Institute of Technology. In 1898 he entered the drafting room of the Logan Iron Works, becoming secretary of the company in 1909, which position he held at the time of his death.

He has been identified largely with the design, fabrication and erection of shields and caissons, and with general foundation work in connection with the building of subways and tunnels.

THOMAS HILL

Thomas Hill, vice-president of the Electric Wheel Works, died at his home in Quincy, Ill., on May 27, 1914, after a long illness. Mr. Hill was a native of England, where he was born in Newton, Wales, on May 3, 1840. He came to

the United States at the age of 21, locating at first in St. Louis, where he remained during the Civil War, working on government boats in the river. In 1866 he removed to Quincy and entered the employ of the Smith-Robertson Company. Here he rapidly advanced to an interest in the concern, which became known as the Smith-Hill Elevator Company. As Mr. Hill had made a number of improvements on elevators and held patent rights, the company dropped all machine work and devoted itself entirely to the manufacture of elevators.

When the Otis Elevator Company absorbed the Smith-Hill company, Mr. Hill went to Chicago, but remained only two years. He became interested during that time in an engine and formed the Quincy Engine Company, acting as president of the concern. At the same time the Ellington Manufacturing Company and the Electric Wheel Company were formed and Mr. Hill was made president of the former and vice-president of the latter.

RODNEY C. PENNEY

Rodney C. Penney was born in East Addington, Me., on November 11, 1853, and was educated in the schools and the Eastern Maine Conference Seminary of Bucksport, Me. His first shop experience was with his father at St. Johns, N. B., and his apprenticeship was served in the shop of the Bangor and Piscataquis R. R. of Oldtown, Me., also under his father who was master mechanic of the railroad. He served for a short time as locomotive engineer on the Bangor & Katahdin Iron Works of Brownsville, Me., and in 1885 became general manager of the Mouson, Me., Slate Company. Twelve years later he came to Bangor as general manager of the Hinckley Engineering Iron Works, and during this time was instrumental in consolidating his firm with the Bangor Foundry & Machine Company, under its present name of the Union Iron Works.

With several others he then formed the Penobscot Machinery Company of which he became president and manager. At the time of his death he was acting as Eastern representative and mechanical engineer of the Dodge Manufacturing Company.

Mr. Penney served for a short time in the Senate of the Maine Legislature.

M. W. SEWALL

M. W. Sewall, who died at his home in New York on May 27, 1914, was born in Brownville, Me., on August 2, 1852, and received his technical education in the Maine State College of Agriculture and the Mechanic Arts, graduating in 1875 with honors. In the following year he entered the employ of the Baldwin Locomotive Works in Philadelphia. In 1878 he became head draftsman for the Edge Moor Iron Company, and had subsequent experience as draftsman and superintendent of erection on machine and boiler shop tools, for Hilles & Jones of Wilmington, Del., and in designing, erecting and fitting up the new shops of the Yale & Towne Manufacturing Company. In 1884 he became assistant engineer of the Pneumatic Dynamite Gun Company of New York, where he had charge of the erection of guns on board the U. S. S. Vesuvius. He was also for a short time with the Cable Road of New York, where he had charge of designs of winding machinery.

At the time of his death he had been in the employ of the Babcock & Wilcox Company, New York, for 22 years, having had general supervision of the drafting room for the earlier part of this period, and devoting his time of late to experimental work on chain grate stokers, furnace design, and improvements in boiler settings. He had made a number of inventions in this field.

Mr. Sewall was esteemed by all who knew him for his conscientious spirit, upright character and gentleness. He was unselfish in imparting the results of his experiments to others and was ever ready to lend a helping hand to those about him.

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

In the first section, on Fuels and Firing, will be found articles on a new type of firedoor designed by the Vulcan Shipyards in Germany, as well as a rather peculiar arrangement for regulating the draft in a chimney or stack by means of a wind wheel driven by the upward current in the stack. In the next article are described several types of grates developed in Russia, mainly for use with anthracite fuel, and a new process for manufacturing peat, brought out in the same country, and based on a rather interesting observation that the moisture contained in certain kinds of peat can be easily driven out by mechanical means, but with other kinds this cannot be done. A good fuel can be produced by mixing the two kinds of peat.

Data of tests on high-speed hydraulic forging presses, and description of a valve used for regulating the hydraulic pressure in this kind of machinery, are of interest in view of the comparatively meagre data available on this subject. An article reporting tests on a 15-h.p. Diesel engine contains an explanation of the fact that while small engines show a decrease of additional friction with an increase of load, large engines behave in an exactly opposite manner; the same article establishes also the relation between the temperature of cooling water and internal friction in the engine at various loads on the engine, and gives data on the maximum temperatures prevailing in the engine during the combustion part of the cycle. It is brought out that the maximum temperature is found not at maximum load on the engine, but at a certain average indicated pressure.

Particular attention is called this month to the section on Machine Shop processes. Guillet and Bernard discuss various methods of producing limited case-hardening; that is, preventing certain parts of the surface from becoming carburized. After discussing the use of copper and nickel deposits on the parts of the surface where carburization is not to take place, the authors show that tin, notwithstanding its low melting point, can be used to advantage in certain cases.

In the same section Grebel describes a special type of furnace for heat treatment of metals heated by coke-gas mixed with heavy-oil vapor, the oil not being passed through the fuel bed, but vaporized separately. Further will be found an extensive abstract of the very interesting account of tests made on various kinds of tool steel by Denis, of the French Army.

In other parts of the Foreign Review will be found articles on improvements in the design of Parsons turbines, strength of cement cubes, power transmission by belt and ropes, etc.

An interesting paper on boiler superheaters and their performance is abstracted from the proceedings of the Franklin Institute. W. D. Ashton Bost, in a paper before the Institute of Marine Engineers, discusses the various uses of wood charcoal, and gives data in connection with its use on ships as an insulating material on refrigerating apparatus. According to figures from Board of Trade reports it would appear that the results of fire are less disastrous where wood charcoal is used for insulation than where the incombustible silicate cotton is employed for this purpose. Data on steam regenerators, a piece of apparatus about which there appears still to be a good deal of question, are presented in several papers before the Engineers' Society of Western Pennsylvania.

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

FOREIGN REVIEW

Fuels and Firing

Machine Made Peat and the Process of Baron Traubenberg (*Mashinofarmorannig torf i sposob barona Traubenberga*, Professor K. Blacher, *Proceedings of the Russian Imperial Technical Society* (in Russian), vol. 48, no. 5, p. 97, May 1914, 15 pp., 7 figs. *d*). The author discusses the machine method of peat briquette manufacture in general and the process of Baron Traubenberg in particular. The essential elements of this latter are first, in the operation of peat digging, the shifting of the bucket arm so as to make it possible to take peat from various depths of the bog separately; and second, the placing of the dredge conveniently with respect to the bog so as to prevent breakages of the bucket arm. The next novelty in the process is based on the fact observed by the inventor that it is quite easy to eliminate water mechanically from peat taken from the upper part of the bog, while it is practically impossible to accomplish this with the fat peat lying at the bottom of the bog. He introduces, therefore, a method of mixing the two kinds of peat, having previously mechanically dehydrated the softer peat of the upper layers of the bog. The system therefore involves the use of two conveyors, a rear conveyor and a side conveyor. The upper level of the peat is taken by the rear conveyor which delivers it to a press for forcing out the water; then the peat is mixed right in the machine with the heavy peat from the lowest level, taken by the side conveyor. It appears that the peat obtained in this manner is much more stable than one not made of a mixture of the two kinds.

The author, together with his assistant, engineer Douglas, have found the following methods for the determination of the *stability of peat:* they made little peat balls weighing 50 g and dropped them from a height of 1 m on a glass plate. In accordance with the stability of the mass the balls spread more or less. The ratio between the two diameters of the mass after it has spread, normal to one another, to the square of the diameter of the ball expressed the stability of the mass in percentages, equivalent to the increase in the projection of the mass after it has struck the glass. A table given in the report shows interesting figures where the projection of the ball increased from 33 to 227 per cent. As regards the properties of the briquettes made by this process, it may be considered to be established (statement of the author) that such briquettes are more regular, less

liable to crack, and when they do crack, form regular and uniformly distributed lines. The author describes an extensive test made by this process in Russia.

Novelties in Solid Fuel Firing Plants (*Neuerungen an Feuerungsanlagen für feste Brennstoffe*, Pradel. *Feuerungstechnik*, vol. 2, no. 16, p. 273, May 15, 1914. 4 pp., 10 figs. *d*). The article describes various new inventions proposed for use in firing with solid fuels. Among other things Fig. A shows a device for cooling the furnace front, patented in Germany by the Vulkan Shipyard Company. This device permits very effective cooling of surfaces forming the parts of the frame which are particularly exposed to the heat of the furnace, by means of a stream of air regulated by a special distributor. The parts which are especially in danger of being affected by the heat are built-in in the firedoor frame as separate pieces, so that they can be taken out and put in again by a simple manipulation of a few bolts without the necessity of pulling down the entire firedoor installation. As shown in Fig. 1A, the removable part *b* is connected with the fire-door frame *a* by an anchor bolt *c*. The cooling is done by means of a compressed air stream going from the Howden draft through the regulating valves *d* which are connected with the firedoor by a lever device, and, according to their setting, provide a more or less effective cooling of the removable pieces *b*. From the latter the preheated air flows through the openings in the frame *a* to the combustion chamber. The weight *g* is connected by means of a knee-lever and an adjustable intermediate piece with the lever *f* which may be shifted in its bearings and which in its turn moves the forked-shaped lever *e* and thereby determines the position of the valve *d*. This valve in its turn opens in such a manner as to permit the flow of the incoming cooling air on the exchangeable part *d* of the frame *a*. When the firedoor is opened the valve *d* is closed.

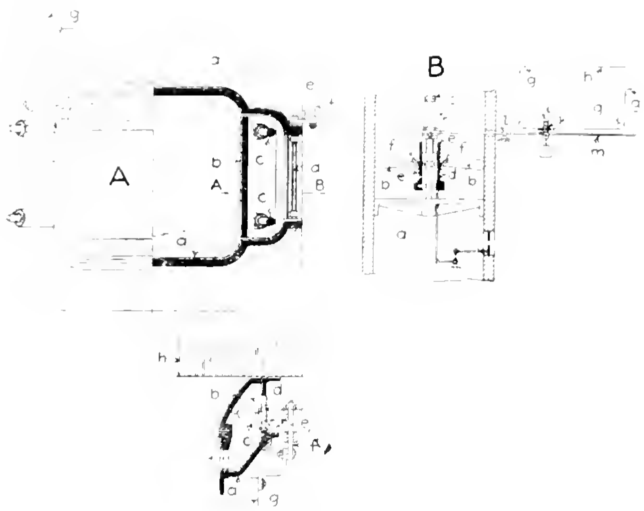


Fig. 1 Novel Appliances for Firing Solid Fuels

The same article describes the peculiar arrangement for the regulation of draft in a smokestack, patented in Germany by E. Hartz. It consists of a centrifugal governor located in the smokestack and more or less closing the free opening of the latter. This governor is regulated by means of a windwheel, driven by the smokestack draft. Fig. B shows one of the possible designs of this governor, consisting essentially of the windwheel *b* built-in in the smokestack *a* and the governor *c* sitting on the shaft of the windwheel. Blades of the windwheel are rotatable about their horizontal longitudinal axis running in the journals *d*, and rotate with the speed corresponding to the existing draft in such a manner that the opening of the smokestack is closed more or less. This rotation is regulated from the governor *c* through the spindle *e*, set on the governor sleeve and connected with the blades of the windwheel through the gear segments *f*. When the draft in the smokestack is at its maximum, the governor arms are at their maximum, the angle of rotation and the blades of the windwheel are so far thrown out around their longitudinal axis by the gear *e f* that the opening of the smokestack is entirely closed. This cuts out the draft and causes the arms of the governor to sink down which again causes the blades of the windwheel to open fanwise. In order to adjust the governor to a certain draft capacity from the outside an endless valve rope *h* is provided, starting from the furnace and going over the rollers *g* to the governor. This rope is provided with a guide piece *i* with the slot *s* in which moves the axis of the roller *k* with the weight hanging on to it. The roller runs along the lever *m* supported on bearings *l* and connected on to the governor sleeve. By pulling on the rope *h* in either direction, the weight is disposed of so as to bear on the lever *m* and the governor may be brought into any desired position of adjustment.

Firing of Coal and Anthracite, and Utilization of Their Heat in the Boiler Room (*Verbrennung von Steinkohlen und Anthrazit und Verwertung ihrer Wärme im Kesselhause*, Professor Kirsch. *Feuerungstechnik*, vol. 2, no. 18, p. 308, June 15, 1914 (and following). *de*). The article describes the properties of Russian anthracite coals and the various methods of utilization of their heat in the boiler rooms. It goes into considerable detail as regards the construction of grates used with anthracite fuel and describes the Kudlitz, Meldrum, Wilton and other types. The following are the constructions developed especially in Russia; the *Idelson* grate (Fig. 2A). Contrary to the Wilton grate, it has a level surface which, in order to make the installation easier, is so built that it can be removed. The construction, however, is more complicated and permits the flow of air to

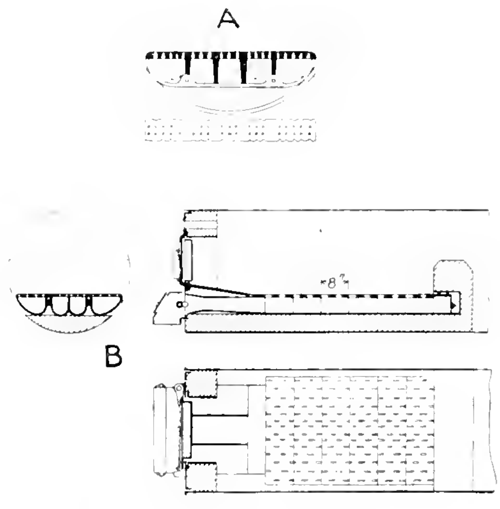


Fig. 2 Idelson and Pawlowski Grates for Anthracite Coal

easily cool the fire owing to lack of metallic contact between air and the grate bodies. A simpler and more durable construction is that proposed by Pawlowsky, shown in Fig. B. The single members are considerably wider than either in the Wilton or Idelson grate (about 8 in). The grate is also level and the openings are in the form of slots. The single members are set on top of the connecting bolts, just as is in the more recent designs of the Wilton grate.

Tests made by the author have shown that an uninterrupted delivery of coal does not produce any improvement in the combustion process, but he still finds it preferable to use mechanical stoking where large amounts of anthracite are burned per unit of time as it produces a decrease in the manual labor which must not be left out of consideration.

All the above described grates can be easily provided with such a mechanical stoking, which, with anthracite firing specially, has a further advantage that it does not permit very large lumps of coal to fall on the grate, the use of small pieces improving the process of combustion in all the above grates. These were provided with very simple steam jet apparatus, consisting of an air nozzle with a steam nozzle built in. Regulation of such an apparatus is easily effected by varying the steam pressure by means of a throttle valve. It is advisable to provide this kind of apparatus with a manometer so as to lighten the work of the fireman and to show that he does not spend too much steam on the blast. It is also advisable to have some simple pressure measuring device connected at one end with the ash-pan and the other with the fire-room. This simple and cheap apparatus will permit one to get an idea of the uniformity of the fuel bed, the degree of cleanliness of the grate and the stresses occurring in the latter (the original article is not finished).

Hydraulics

On Water Admission Steering Gear for High Speed Forging Presses and their Investigation by means of No Load Diagrams (*Über Vorfüllsteuerungen für Schnellschmiedepressen und ihre Untersuchung durch Pressenleerlaufdiagramme*, Adolf Kreuser. *Stahl und Eisen*, vol. 34, no. 25, p. 1043, June 18, 1914. 4 pp., 13 figs. *de*). In order to reduce the resistance occurring in the admission of the pressure water, as well as the concomitant fall of pressure, the J. Banning Company of Hamm in Germany has designed the special valve shown in Fig. 3A. One can see at once the advantageous path of water on account of the inclined position of the valve and because of the fact that the valve opens directly into the large water space of the pressure cylinder. The valves are also easily accessible; a valve like that shown in Fig. A has been used on forging presses with capacities up to 1000 tons (metric, equal to 1100 short tons).

A clear conception of the internal relations in a hydraulic press during the no-load stroke can be obtained by means of indicator diagrams. Figs. B to D show the indicator diagrams taken during the downward stroke of the plunger of a high-speed hydraulic forging press, used on the Italian State Railways. The water end pressure in the tank, at the time the diagram B was taken, was 0.9 atmospheres gage. The time which the plunger required for the no-load stroke of 0.53 m (1.69 ft) was 1.0 sec., measured by a stop-watch, this making the average downward velocity of the press plunger 0.53 m (1.69 ft.) per sec. On account of the hydraulic pressure, the plunger was receiving throughout its path an additional acceleration. Previous to taking diagram C, the water pressure in the tank was reduced by blowing off part of the compressed air and as diagram C shows, the water pressure was producing an acceleration on the plunger during its nearly entire no-load stroke. The hydraulic end pressure in the press cylinder was just equal to atmospheric pressure so that shortly before the end of the stroke, the water did not affect the motion of the plunger any more. Previous to taking diagram D, the water pressure in the tank was still further reduced, and the hydraulic pressure produced an acceleration of the plunger motion only at the beginning; after the plunger had traveled through part of its stroke, the water pressure in the cylinder fell below the atmospheric, and the plunger carried the water with it by suction, just as in a suction pump. Here also, however, the process in the press cylinder occurred without shocks, as the water column was not broken, and the cylinder was full of water at all positions of the plunger. The average downward velocity of the press plunger was in this case 0.44 m (1.44 ft.) per sec.

The diagrams E, F, and G have been taken from a steam hydraulic high speed forging press, used in the central shops of the Royal Railroads at Meiningen. At the same time when these diagrams were taken, special indicators were used

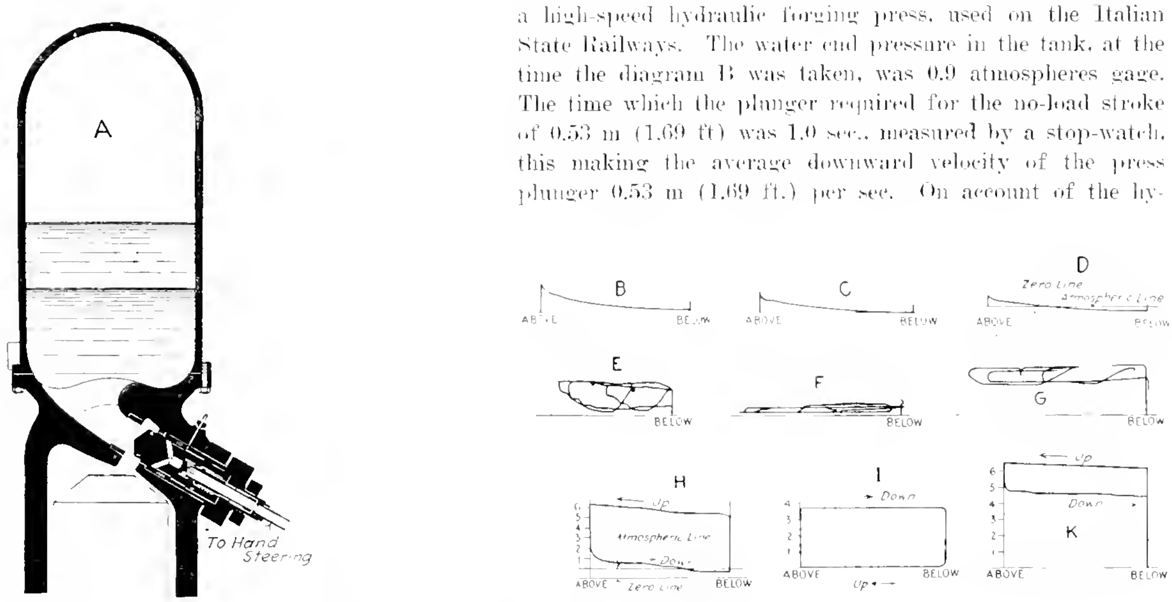


Fig. 3 High Speed Hydraulic Forging Press Valve and Indicator Diagrams

to indicate the various spaces influenced by the no-load stroke, namely, in Fig. E, the press cylinders, in Fig. F, the upper steam return space and in Fig. G, the lower steam return space. The diagrams indicate the increase and decrease of forces during the no-load run, produced by causing shorter or longer strokes to follow one another. Of particular interest in this case, is the variation of steam pressure in the lower steam space. The steam consumption for the no-load stroke in the present case is very small because the live steam admitted to the lower steam space during the working stroke has in every instance found non-consumed steam of about the same pressure still there. Figs. H and K show no-load stroke diagrams for the upward and downward strokes of the press plunger of a steam-hydraulic high speed forging press when the most rapid reversal by hand operated lever was used. The press is of the same construction as that to which refer the diagrams E, F and G. The author discusses further the frictional resistances in the press plunger action. In addition to the forces shown by these indicator diagrams, the press plunger has to overcome also frictional resistance, which can in the case of a slow motion of a plunger be analytically determined from the indicator diagrams. The author shows how this resistance can be obtained from the diagram H. The frictional resistance has a certain importance on the motion of the plunger and therefore must be reduced as much as possible.

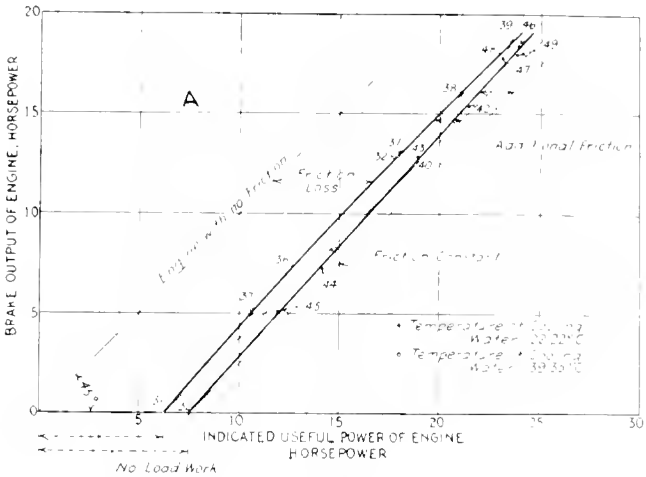
The Turbine Plant of the Günther and Richter Paper Manufacture in Wernsdorf (Saxony) Built by Escher, Wyss and Co. of Ravensburg (*Die Turbinenanlage der Papierfabrik von Günther and Richter in Wernsdorf (Sachsen), erbaut von Escher, Wyss & Cie. in Ravensburg*, Fr. Freytag. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 26, p. 1033, June 27, 1914 (and following). *d*). The article describes the turbine plant of the paper mill of Gunther & Richter in Weinsdorf (Germany). The new installation of the water turbines was put in in 1912, when several plants, formerly separate, were united in order to make their operation more efficient and economical. There was formerly a set consisting of one Girard turbine and one Francis turbine with vertical shafts which with a 5 m. head (16.4 ft.) could deliver at most 200 h.p. The new installation is calculated to deliver up to 1500 h.p. The installation was especially difficult to design owing to the water-power plant and mill where the power is used being pretty well apart and through the fact that while twin turbines with horizontal shafts had to be selected, a variable water level required the division of the power plant into three groups. It was therefore decided to put up the turbines with a high suction upper water level (Escher, Wyss and Co. system) and to connect them direct onto the shaft of the polishing plant. The middle line of the shaft lies 440 mm (17.3 in.) above the normal upper water level. The runners have an entering diameter of only 600 mm (23.6 in.) and the lower edge of the runner is at least 140 mm (5.5 in.) over the upper level of the water. The turbines (three Francis twin type) of equal dimensions are directly connected to two horizontal shafts. Their runners have a speed of 237 r.p.m. They all have rotatable blades with automatic regulation and hand regulation. The water comes onto the distributors from below and each turbine is covered over by a cast iron horizontally divided arc-shaped cover whereby a reliable airtight water chamber and convenient flow of water is obtained. In the case of material repairs, these covers may be easily lifted off, in which case the entire turbine is fully accessible from the machine shop.

Internal-Combustion Engines

Tests of a 15 H.P. MAN Diesel Engine (*Untersuchungen an einem 15 pferdigen MAN-Dieselmotor*, F. Münzinger. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 26, p. 1049, June 27, 1914, 7½ pp., 24 figs. *e*). The article describes tests on a vertical Diesel engine built by the Augsburg-Nurnberg Works (the tests were performed in the mechanical laboratory of the Berlin Technical High School). The engine was rated at 15 h.p., has a working cylinder 215 mm (8.4 in.) in diameter and 340 mm (13.3 in.) stroke and compressor cylinder, in two stages, 100 mm (3.9 in.) stroke running at from 230 to 240 r.p.m. The load on the engine was put on by means of a Prony brake of special construction, while the diagrams have been taken by a Maihak indicator of convenient design and properly calibrated.

One of the questions in the construction of gas engines which cannot be as yet considered to have been cleared up is whether the friction work of an engine increases or decreases with increasing load; that is, whether the supplementary friction of an engine is positive, constant or negative. To determine this, two series of tests with variable load and variable temperature of cooling water were undertaken. Fig. 4A indicates clearly the great influence of the temperature of cooling water on the amount of friction work. If two parallel lines be drawn through the no-load points of the two tests at 45 deg. to the horizontal, then the horizontal distance between these two curves and the curves passed through the points obtained by actual tests, will indicate the magnitude of the additional friction in both series of tests. The additional friction decreases with the increase of load. In order, however, to establish whether the decrease of the additional friction with the increase of load is peculiar only to the engine tested or common to all Diesel engines, the author calculated results for other sizes upon which data are available. His curves show that when the load on an engine increases, there sometimes occurs an increase and at other times a decrease in the work of friction, but a certain law can be seen to cover this variation when the size of the engine is taken into consideration, since it appears that with an increase of load the small engines show a decrease of additional friction while the large engines show an increase. The main reason why the additional friction would decrease with increasing load is to be looked for in the decrease of piston friction. The plunger piston of a Diesel engine is usually turned in such a manner that its lower end directed towards the external atmosphere has a slighter angle of incline than the upper end. When the load increases the temperature of the wall, along which the cylinder runs, increases also and as a result the cylinder expands more than the piston and this permits an increase of play between the piston and cylinder. Of course the diameter of the piston increases also under these conditions, but since the piston in the part directed towards the combustion space is narrower than the cylinder bore, even at a maximum load, no jamming between the piston and guide can occur; the expansion of the lower part of the piston will always be less than that of the surfaces of the cylinder. In addition to the favorable action of the increase of piston play on the reduc-

tion of friction, the increased lubricating effect of the lubricating oil, due to the higher temperature of the cylinder walls, also acts towards reducing friction. This explanation of the decrease of additional friction with increase of load is supported by the great influence of the temperature of cooling water on friction losses shown by the present tests. The rise of the average temperature of the cooling water in the jacket of the cylinder increases the play between piston and cylinder in the same manner as the increase in temperature of the cylinder which is produced by an increased transmission of heat from the gas mixture to the cooling water. This does not yet answer the question why in larger engines the friction increases with increase of load. It appears, however, that from a certain cylinder diameter on different conditions come into play, viz., the variation of expansion of piston and cylinder play smaller parts and at higher load the smaller piston friction is more than compensated by the



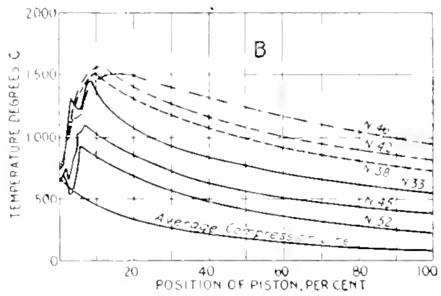


Fig. 4 Tests of a 15 h. p. Diesel Engine. (A) Relation Between Friction and Load. (B) Temperatures Occurring in the Cylinder

increase of friction in the bearings, etc. The present tests do not, however, give a complete answer as to this fact.

The author proceeds to establish, largely by graphical methods, the "heat balance" of the engine. He finds that the indicated theoretical efficiency of the Diesel engine process increases with the decrease of load owing to the rise of the expansion ratio. The thermal efficiency of the theoretical cycle was found by calculating the end compression pressure and by assuming that the heat was brought in at that particular pressure. Then the compression and expansion lines were plotted by assuming for the temperatures corresponding to various positions of the piston, the values calculated from the usual formula which takes into account the variation for the exponent for various temperatures.

It is particularly important to know how the temperature varies during combustion and expansion and what the maximum temperatures obtained in the engine are. While this latter could not be calculated with absolute certainty, the possible errors are so small that the data can be fully used for all practical purposes. Fig. B shows that the maximum temperature in the engine does not exceed 1500 to 1550 deg. cent. (2732 to 2822 deg. fahr.) and that the highest temperatures occur not at the highest load on the engine, but at an average indicated pressure of about 7.4 atmospheres. From there, the upper part of the temperature curve becomes generally flatter and remains in the neighborhood of 1500 deg. cent. (2732 deg. fahr.).

Machine Shop

Limitations of Case-Hardening and Diffusion Through Solids (*Les réserves en cémentation et la diffusion dans les solides*, L. Guillet and Victor Bernard. *Bulletin de la Société d'Encouragement pour l'Industrie nationale*, vol. 121, no. 5, p. 588, May 1914, 30 pp., 32 figs. *pe*). The article discusses methods of carburizing by which certain sections of the surface can be left untreated and also takes up the subject of the diffusion of metals through solids. As regards the first, the author calls attention to the usual methods of protecting the surface of case-hardened articles in the parts where no carburization is desired. This may be done by either of three methods, that is (1) covering the parts to be protected by some refractory material, (2) "piping," and (3) case-hardening the entire surface and then cutting off a certain thickness on the parts where no case-hardening is desired, such parts having previously been made somewhat thicker so as to compensate for the material removed in the later process. The method which appears to be most convenient for general purposes is that of covering the parts to be protected by a layer of some metal which will prevent carburization. Such a metal must satisfy the following conditions: (1) It must be solid at the temperature of the operation as otherwise it would flow and leave the surface unprotected; (2) it must not allow the passage of the substances which produce carburization, and (3) it must be easy to apply under shop conditions and, after carburization, if necessary, must be easy to remove. So far there are two metals which can be generally considered, copper and nickel, but the author has made some experiments with tin which appears to be also applicable in this connection notwithstanding its low melting point. There are several methods of laying copper over iron. The immersion of the article into a solution of copper salts or the painting of the parts of the surface by such a solution appears to be at first sight very attractive on account of its simplicity, but no good results could be obtained in this way partly owing to the very slight thickness of the metal layer and partly because of its irregular structure and lack of unity and adherence. A far more reliable method is electrolysis. The authors tried to determine the minimum thickness necessary and sufficient for an absolute protection of iron against carburization under conditions prevailing in the case-hardening process, these conditions being established by the thickness of the carburized layer obtained in the parts not protected by copper. These results will be reported below. The third method of coppering an iron surface was by the Schoop process of metalization which as compared with the electrolytic deposit gives an irregular grain-like layer and unlike the other does not admit of a sufficiently precise measurement of

TABLE 1 RELATION BETWEEN THICKNESS OF PROTECTING LAYER OF COPPER AND AMOUNT OF PROTECTION AFFORDED

Temperature of Case-Hardening, Deg. Cent.	Thickness of Carbonization in Not Protected Parts, mm.	Thickness of the Protecting Layer of Copper (1/100 of mm.)	Carbonization of Protected Parts
1000	1.0 to 1.1	1 to 2	slight
1000	1.0 to 1.1	2 to 3	absolutely none
1000	1.8 to 1	1 to 2	considerable
1000	1.8 to 2	3 to 4	absolutely none
850	1.0 to 1.1	1 to 2	absolutely none

thickness. On the other hand, however, the metalization process permits obtaining with great rapidity a fairly thick layer and therefore does not essentially require a knowledge of the minimum sufficient thickness of layer. In the case

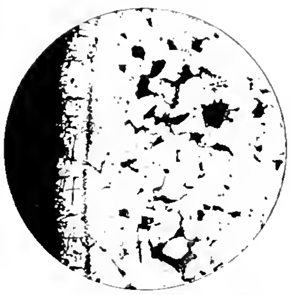


Fig. 5 Micrograph of a Piece Partly Protected in Case-Hardening by a Layer of Tin

of electrolytic deposition of copper, the measurement has been effected in 1-100ths of a mm. The electrolysis was obtained in a cyanide bath and the carburization made from a mixture of 60 parts by weight of charcoal and 40 parts of barium carbonate. Results obtained are shown in Table 1, which indicates that the thickness of the deposit necessary for the protection of the iron against case-hardening is a function of the temperature and duration of the carburization process.

The nickeling of iron can so far be done only by electrolysis as pulverization methods have not yet been applied to this metal. Tests similar to those on copper have been made also for nickel deposited from a double electrolyte of sulphate of nickel and ammonium. It appears, however, that contrary to the case of copper, nickel is not a good protective agent and only delays the carburization to a certain extent, which shows that it is permeable to carbon monoxide.

Tests have been also made with protecting iron by a layer of tin which is of interest on account of the great simplicity of the application of this metal, and it appears that notwithstanding its low melting point it gives very good protection. Its use is, however, limited to plain surfaces which can be maintained horizontally during the carburization. Otherwise, it gives a very regular protection or none at all. In addition the edge of the piece appears to be strongly altered (Fig. 5). The above shows that practically copper alone gives the solution of the problem of protecting iron against case-hardening by means of a metallic deposit. As regards the best method of applying this deposit, the Schoop process is extremely simple, but unless it is used in the same shop for other purposes, may prove too costly on account of the large cost of installation and royalties paid. The electrolytic process is cheap to install, practically automatic in operation, consumes very little copper, but is inferior to the Schoop process from the point of view of localization of deposits. The second part of the article is devoted to discussion of the diffusion of metals through solids.

Furnaces for Heat Treatment of Metals Running on Producer Gas Enriched by Heavy Oil (*Fours pour le traitement thermique des metaux, chauffés au gaz de gasogène enrichi à l'huile lourde*, A. Grebel. *Le Génie Civil*, vol. 65, no. 7 and 8, pp. 136 and 160, June 13 and 20, 1914, 5 pp., 9 figs. *dge*). The article describes in detail the use of producer gas enriched by tar-oil for heat treatment of metals and in particular the furnace and methods used by the French concern, "Air et Feu" (Air and Fire). The Air and Fire system furnace shown in Fig. 6A and B comprises as its essential parts, gas producer *A*, carburetor *B*, the combustion chamber *C* and heat recuperator *D*. When the operations are such that the doors have to be frequently opened as, for example, in forging, stamping and tempering, the combustion chamber is placed on an elevation so as to create a slight pressure of the gases in combustion. In the furnaces designed for long operations with the doors closed air tight, the design shown in Fig. C to E, with all parts very nearly in one plane, is preferable. Fig. F shows how the oil is brought to the carburetor B and how it is used for igniting the producer gas in the mixing chamber every time such an ignition is desired. The blast used permits obtaining intensive gasification as well as short and constantly hot flame, but on the other hand does not permit obtaining regular and uniform temperatures in an enclosed space, and as a consequence it does not guarantee in any way a uniformity in the combustion of the flue gases and their content of free oxygen as required in many heat treatments of metals. When the blast is used, therefore, either a complicated system of blowing or the most strict supervision of the regulation of combustion or both have to be maintained. To obviate this difficulty, the author, under whose patents the Air and Fire system furnaces have been designed, has undertaken to have his furnaces work at low drafts; for furnaces of average commercial size and larger, it appeared rational to adopt the independent type of gas producers, built in one unit with the combustion chamber and heat recuperator so as to reduce radiation losses and utilize to the maximum extent the latent heat of gases coming from the producer. To build and operate special producers for rich gases from fuel containing large amounts of volatile matter is expensive, while coke gas producers with a slow rate of production and simple grates are very easy to build and operate. Gas coke which is light and brittle, is not used for metallurgical purposes or for small furnaces with direct flame when it is desired to obtain a high temperature. It is, however, quite convenient for use in gas producers with low draft and, on account of its low price, very desirable for use in heat treating furnaces, if it can be used conveniently, which as the author claims, can be done in the furnace described in the present article. The quantity of water introduced into the producer is controlled by means of regulator *a* of a construction analogous to that of the oil regulator *b*, shown in Fig. F, and the construction of which will be explained in more detail

below. This is done because the amount of water admitted to the producer has to vary in accordance with the rate of output of the latter. In order not to cool the producer furnace too much while it runs at low rate of output, the amount of water admitted must be then extremely small, while, when large producers are working at full rate, up to one lb. of water per lb. of coke can be admitted.

This statement of the author is of importance because of the opinion expressed by certain designers of producer furnaces who, without denying that the amount of hydrogen in the producer is of advantage from the point of view of the amounts of heat utilized in the combustion chamber, state that the products of combustion must not affect the articles submitted to the heat treatment, and that if the combustion has been perfect and correct, without an excess of air, they must in addition to nitrogen contain only carbon dioxide and steam; that further, the latter tends to decompose when in contact with hot metal and to oxidize it. From these correct premises, they make a wrong conclusion, namely, that the amount of water admitted into the producer must be reduced to as low a limit as possible. What may be called neutral combustion, that is, one producing neither carburation nor oxidation, varies with the circumstances. In the case of autogenous welding where the temperature of the flame is in excess of 2000 deg. cent. (3632 deg. fahr.) and the products of combustion are not diluted by nitrogen, the carburation is sometimes to be expected while oxidation is practically imminent, and is all the more to be feared as it compromises the results of the operation. But it is easy to establish by calculation and verify by direct tests that in the products of a perfect combustion of a mixed-coke-gas containing, for example, 13 per cent of hydrogen and only 22 per cent of carbon monoxide, the steam contents do not exceed 9 per cent, so that, at the usual low temperatures below 1500 deg. cent. (2732 deg. fahr.), such as occur in furnaces under consideration in the present case, there is much less danger of oxidation when mixed-coke-gas is used than when water gas or especially coal gas is used, and, further, the system of regulation used in the present furnace makes it possible to admit as little water as desired; on the other hand, even when a liter of water is admitted per kg. of coke, all the water is certainly vaporized before it reaches the grate through the intense radiation directed towards the stationary trough which is located within the door and where the water arrives first. With mixed coke producer gas having a hydrogen content of approximately 12 to 15 per cent escaping hot from the producer and burned with not-blown secondary air, heated previously by the flue gases, the temperature of 1450 deg. fahr. (2612 deg. cent.) may be considered as an absolute maximum even in small furnaces.

In order to obtain higher temperatures one must have recourse to the use of richer fuels, preferably fuels comparatively poor in hydrogen. Neither acetylene nor gasoline vapor nor even coal gas can be considered in this connection owing to their high prices and only less refined products such as heavy tar-oils (which have already been successfully used in special furnaces) can be considered for this purpose at a comparatively low price. They have an average heat value: upper limit 9450 cal. (17010 B.t.u. per lb.), and lower limit 9050 cal. (16290 B.t.u. per lb.). Notwithstanding the great difference in the initial price of 1000 heat units as gas coke or heavy oil, the heavy oil furnaces could stand comparison with the coke producer gas furnaces for small units intermittently used when developing a high temperature.

Whereas in certain kinds of burners provided with a producer or "boiler," the oil is simply gasified, in the present design the carbureter *B*, Figs. C and F, has been placed in the region of the gas flue where the temperature of the oil does not exceed 360 deg. cent. (680 deg. fahr.). In this way, the total vaporization of the oil may be secured and at the same time "cracking" is avoided. The temperature of the gas coming out from the producer has been somewhat reduced in order to have in the combustion chamber a gas free from dust; still, the temperature is too high to let the gas flow over the surface of the oil. The current of the gas carries, however, vapors as they are formed. The surface of vaporization in the boiler *B* has a horizontal section, decreasing with consumption of the oil. The oil vapors, not previously denatured by heat, become diluted in the mixed gas of the producer, and thereby particularly susceptible to enter into an intimate mixture with the air of combustion. In this way, the gas is made richer without there occurring a transformation of the carburizing material, contrary to what happens in the case of gas producers, where tar or heavy oils are injected over the coke bed or incandescent refractory materials.

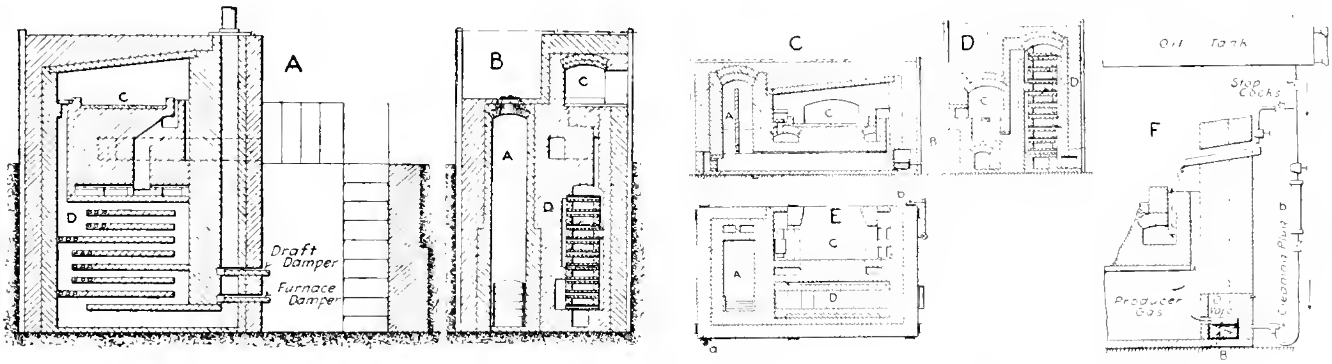


Fig. 6, A to E Air and Fire Company's Furnace for Heat-Treatment of Metals

Combustion Chamber. Although the diffusion of the very heavy vapors of the coal-tar oil through poor gas facilitates their complete combustion, the question of the quality of the flame still remains very delicate. The burners have been designed in such a manner as not to create any localized combustion and exaggerate the parallelism of the currents of gas and air. It was found that contrary to what has been stated in certain books of theory, it is not necessary, in order to obtain a uniform temperature, to extend the length

of the flame so that "the combustion should occur outside of the furnace." If this is done, the best temperature of the flame is lowered owing to the retardation of the combustion and, in addition, reducing and oxidizing streamlets of gas and air are created, producing an undesirable influence on the heat treatment process. When the thermal potential of the gases of combustion is sufficiently above the temperature at which the heat is utilized, the exchange of heat is more rapid and the heating of the heat-treated pieces can be carried on with a quiet flame; the caloric efficiency is better than in the case when the velocity of circulation of the flames is intensified, and further, the heating atmosphere is more homogeneous. In heat treating furnaces, it is therefore important to select in a judicious manner the length of the flames, disposition of the burners and the outlets for the flames. As regards the *recuperation of the heat*, only a simple recuperation in the secondary air of combustion has been utilized.

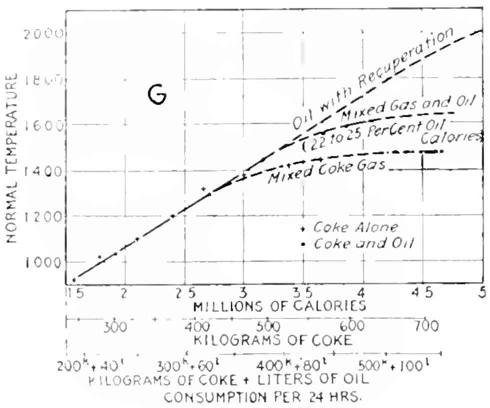


Fig. 6, G Heat Rate of Consumption Curves for Furnaces of Various Types

The recuperation on the primary air which theoretically would be of peculiar interest for furnaces operating at a normal temperature in excess of 1500 deg. cent. (2732 deg. fahr.) leads to complications and to losses in recuperators, larger than the saving due to the large losses of recuperators by radiation, besides making the conservation of the producer grates difficult, and the regulation and maintenance of operation of the furnace, more delicate. It is hardly possible to recuperate any heat from the gas which comes out hot from the producer and is scarcely cooled at all in the dust cleaning flue. In Fig. A and D, it will be noticed that the recuperator *D* is considerably larger than in the furnaces, the surface of which is too much restricted. Last year a number of tests on a horizontal type of furnace of the above described design heated by coke exclusively or coke and heavy oil together, were made by J. Conor, a gentleman apparently connected with the Air and Fire concern. In order to obtain comparable results, the combustion chamber of the furnace was kept closed and filled with refractory materials, and the same conditions were maintained in the other coke gas or oil furnaces, which were placed in parallel with the Air and Fire Company's unit.

The article describes in detail the measurements taken and instruments used for that purpose. The proportion of the heavy oil in case of mixed-combustion varied about two liters per ten kg. of coke which represented the ratio of approximately 23.5 per cent of the total number of heat units consumed. The curves in Fig. G represent normal temperatures as a function of the number of calories expended during 24 hr. (all the tests were reduced to a 24 hr. unit). This number was calculated by assuming 6400 cal. per kg. (11,520 B.t.u. per lb.) as the upper heat value of coke and 9900 cal. as the upper heat value of a liter of oil (density 1.06, upper heat value per kg., 9125 = 16,965 B.t.u. per lb.). It may be stated that at from 900 to 1300 deg. cent. (1652 to 2372 deg. fahr.), the normal temperatures have been found to be substantially proportional to the expense in calories per 24 hr., whether from gasified coke, or from gasified coke and vaporized oil. From 1300 deg. cent. (2372 deg. fahr.) up, the normal temperatures with poor gas from coke producers only, increase less and less rapidly and tend towards an asymptote at about 1450 deg. cent. (2642 deg. fahr.), from 1300 deg. to 1475 deg. cent. (2372 to 2687 deg. fahr.), approximately, when mixed firing is used with 100 kg. of coke per 20 l. of oil (76.4 per cent of coke-calories, and 23.6 per cent of oil-calories), the normal temperatures continued to rise in proportion to the expenditure in heat units, and tend rapidly towards an absolute maximum which may be estimated to be about 1650 deg. cent. (3002 deg. fahr.). To exceed this temperature, the carburation of the oil would have to be forced, and it alone could give a much higher temperature under similar conditions of heat recuperation without "cracking," all other conditions being equal. It appears, therefore, that in a given furnace, the number of calories circulating in the combustion chamber cannot be increased indefinitely and a limit is laid on account of the resistances opposing the movements of the gas and combustible vapors, air of combustion and flue gases. On the other hand, it is not wise to increase the proportion of the oil vapor too much in the mixed-gas, especially at low temperatures with small drafts, since owing to insufficient dilution, it is difficult to burn heavy oil, well. That was the reason why the present tests have not gone behind a 30 per cent ratio of oil-calories in the mixture.

A diagram in the original article taken from tests gives curves for four rates of consumption per hour arranged in such a manner that, in pairs, they might be comparable with one another. The curves of the rise of temperature in the combustion chamber are given as functions of time, the combustion chamber being cooled by the opening of the door to temperatures of 500, 750 and 900 deg. cent., respectively (932 to 1382 and 1652 deg. fahr.). When two million calories per day are consumed in the furnace, the passage from 750 to 900 deg. cent. takes about 1½ hr. with mixed fuel and 3 hr. and 45 min. when poor gas alone is used for heating. With a consumption of three million calories per day, the passage from 900 deg. to 1200 deg. cent. requires, with mixed heating, 1 hr. and 30 min., and with poor gas alone, 3 hr. and 15 min. While the time necessary to re-establish the normal temperature is not entirely lost as far as the operation of heat treatment is concerned, it is easy to see, when such operations are of short length and have to be frequently renewed, how a rapid method of raising the temperature affects the cost of manufacture expressed by a larger consumption of heat or a shortening of the time of operation.

Investigation of the General Properties of Tool Steels (*Étude sur les propriétés générales des aciers à outils*, M. Denis. *Revue de métallurgie*, vol. 11, no. 6, p. 569, June 1914, 100 pp., 43 figs. ecA). The article pre-

sents the results of quite an extensive investigation on the efficiency and output of tools and tool steels. It is divided into three parts: First, discussing the method of tests and heat treatment of various kinds of tool steels; second, the detailed data of the tests, and third, conclusions and general results derived from the data in part two. The third part only will be abstracted here.

The tests can be divided into two main classes, cold and hot tests. As regards the first, two main points, sensitiveness to tempering, and hardness and resilience in various types of treatment have been considered. The results of all the tests are combined in Table 2. The system used by the author is to give a mark 20 to a steel, the Brinell hardness of which is not influenced by an increase of 50 deg. cent. (90 deg. fahr.) in the temperature of tempering. This mark is decreased by as many units as the decrease in the hardness, for an increase of 50 deg. cent. in the temperature of tempering, contains tens of Brinell units. For example, if a steel has a hardness of 800 Brinell units at the best temperature of tempering of 780 deg. cent. (1436 deg. fahr.) and a hardness of 760 for a temperature of tempering of 830 deg. cent. (1526 deg. fahr.), then the mark for the sensitiveness of tempering would be 16, that is 20 — 4. A similar system is used for marking the hardness and resilience of various kinds of steel, corresponding to typical treatments. The best types of treatment were as follows:

TABLE 2 CLASSIFICATION OF VARIOUS KINDS OF TOOL STEEL IN ACCORDANCE WITH DATA OF TESTS OF COLD WORKING

Kind of Steel	Sensibility to Tempering	Sensibility to Successive Temperings	Average Mark for the Three Typical Treatments
Special S_3 (extra-hard chromium)	18	13	18.33
Carbon C_6 ... ... (1.14% carbon)	17	19.5	17.9
Carbon C_7 ... ... (1.26% C)	13	14.5	17.25
Carbon C_4 ... ... (0.91% C)	19	15	17
Special S_1 ... ... (very hard chromium)	17	13.5	16.9
Special S_2 ... ... (very hard chromium)	18	18	16.85
Special S_5 ... ... (tungsten)	16	15	16.66

No. 1	No. 2	No. 3
$\Delta = 800$	$\Delta = 750$	$\Delta = 770$
$\rho = 2$ kgm.	$\rho = 4$ kgm.	$\rho = 3$ kgm.

For each type of steel the mark corresponding to each of these typical treatments has been calculated in the following manner: For hardness the mark is lowered from 20 by as many pounds as the difference between the optimum hardness and actual hardness contains tens of units on the Brinell scale (the mark may be increased under the same conditions when the actual hardness exceeds the optimum hardness). *Resilience.* The mark is determined in accordance with the real value of hardness, and then decreased or increased in accordance with the actual value of resilience, one point in the mark corresponding to a difference of 0.5 kgm between the optimum resilience and the actual resilience. For example, a steel of which the actual hardness and resilience for the three typical treatments is as follows:

No. 1	No. 2	No. 3
$\Delta = 780$	$\Delta = 710$	$\Delta = 740$
$\rho = 2.5$ kgm	$\rho = 3.5$ kgm	$\rho = 3$ kgm

will receive for each of these treatments the marks as follows:

No. 1	No. 2	No. 3
$2 - 2 + 1 = 19$	$20 - 4 - 1 = 15$	$20 - 3 + 0 = 17$

The author has further determined the *sensitiveness* of steels to various successive treatment. The steels have been submitted to several temperings one after another, with annealings between each two treatments. The value of hardness after the fifth treatment has been utilized for classifying the steels from the point of view of their ability to withstand these repeated treatments, the steel of which the hardness does not change after five temperings being with the mark 20, which is reduced by as many points as the decrease of hardness contains tens of units on the Brinell scale. A study of different steels from this particular point

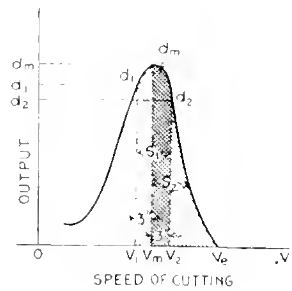


Fig. 7 Characteristic Curve of Output of Tool Steel

of view has led to the following conclusions: First, the resilience increases with the number of temperings to which the steel has been submitted; after the fifth treatment, the resilience of certain steels is nearly doubled while in others it increases by one half. Therefore, if by successive temperings tool steels lose a certain amount of their initial hardness, their resilience rises, and, as a result, the efficiency which depends on the magnitudes of these two characteristic values, will vary less than would have been the case otherwise; second, after ten successive temperings with annealings in between *carbon* steels properly so called with the content of carbon in excess of 0.7 per cent, give quite variable results from the point of view of hardness. These steels have hard parts, the hardness of which is comparable to the initial hardness, and soft parts, the hardness of which goes down to 500 and even 400 Brinell units.

Special steels treated in the same way preserve a uniform hardness in all of their parts, but this hardness goes down as the number of treatments increases. The resilience of both carbon steels and special steels slightly decreases after the fifth tempering, but after the tenth tempering its value is still superior to the initial value. This classification (compare above Table 2) shows that the steel which can give the best results on metal working cold is the extra hard chromium steel S_3, hypereutectoid steels C_6, C_7, and C_1, and hard chromium steels S_1 and S_2. Tungsten steels have lower efficiencies. Special nickel chromium steels are not and have not been included in the table, and have practically no sen-

sitiveness with respect to tempering. Their hardness after tempering is much inferior to the hardness of carbon and special alloy steels, but their resilience is much superior to them. Their sensitiveness to successive temperings is very low. Case hardening followed by a tempering at the bottom temperature gives to nickel chromium steel an optimum hardness of about 720 Brinell points, comparable to the hardness of high carbon steel and special alloy steel tempered but not annealed. "Six per cent" nickel steel possesses after tempering a much lower hardness than preceding steels but a far higher resilience (12 kgm as compared with 5 kgm). It has a very high elastic limit.

Tests while hot. The results of these tests show the heat treatment which is likely to give the best efficiency and the curve of output corresponding to the best utilization of the tool. The following methods have been used to classify various steels from the point of view of their hot outputs and efficiency. The efficiency of tool steel in the operations effected while the steel is hot, depends either exclusively or at least to a very large degree on the value of hardness and tenacity at the temperature at which the tool works. The tenacity of carbon steels and special steels is usually at its minimum around 100 deg. cent. (212 deg. fahr.). Its value rises considerably (to above 2000 kg) at a temperature of 150 deg. cent. (302 deg. fahr.). It increases still further as the temperature rises and reaches its maximum value of 4000 to 5000 kg at temperatures between 200 to 250 deg. cent. (392 and 482 deg. fahr.). The hardness of the same steels, which lies at the ordinary temperature between 700 and 800 Brinell units, diminishes at first in a very noticeable manner up to the temperature of 100 deg. cent. (212 deg. fahr.). It is generally in the neighborhood of 650 units at temperatures between 100 and 200 deg. cent. (212 to 392 deg. fahr.), and very rapidly decreases then as the temperature rises. Except in the case of tungsten steels S_4 and S_5, the hardness is below 550 Brinell units at a temperature of 300 deg. cent. (572 deg. fahr.).

The variation in hardness which is the most important characteristic, produces noticeable variations in the efficiency of steels, while corresponding variations of tenacity have much less influence on efficiency. One can therefore consider the variations of $\Delta^2\tau$ as representing in a sufficiently close manner the variations of efficiency at different temperatures. The author has calculated for each kind of steel, the value of the above expression at temperatures of 150, 200 and 250 deg. cent. and with the average values of them obtained the following equation:

$$C_r = \frac{1}{10^8} \cdot \Delta^2\tau$$

which he calls *coefficient of efficiency* and which permits to classify steels from the point of view of efficiency while hot. The author gives a table of coefficients of efficiency for various steels between temperatures of 150 and 250 deg. cent. This table shows that special steels are likely to give better efficiencies than carbon steels properly so called, and that among the latter, hypereutectoid steels will give a higher efficiency. As regards output, the curves of output obtained by means of the Herbert machine permit to gain a basis for the classification of various kinds of steel.

In order to use these curves of output for the classification of steels, it is necessary to bear in mind the characteristic elements of these curves which are as follows: (1) the best speed of cutting v_m which gives the maximum of output; (2) the maximum of output d_m corresponding to the best speed; (3) the width of the curve about this maximum (variations of output for variations of speed cutting are less pronounced as the curve grows wider in this region); (4) the limiting speed of cutting v_e beyond which the steel is not susceptible of any output and which, together with the best speed of cutting, limits the zone of economic speeds. In Fig. 7 assume that d_1 and d_2 be the outputs obtained with a tool steel with velocities of cutting v_1 and v_2 equidistant from a best velocity of cutting v_m (the equidistance being 3 m); these ordinates d_1 and d_2, the axis of velocities of cutting, and the upper part of the curve of output form the limits of the surface S_1, the extension of which characterizes the width of the curve about its maximum. On the other hand the surface S_2 represents the zone of economic speeds of cutting of the steel and its value characterizes the extension of the curve to the right of the maximum and the magnitude of the limit– speed. The expression

$$F = \frac{1}{100} v_m (S_1 + S_2)$$

using the characteristic elements of the curve of output of each of the steels gives a method of differentiating them from the point of view of their cutting properties and may be called the *characteristic function of the curve of output.* The steels which are likely to give the best outputs are (with the exception of the tungsten steel S_4 which is at the head of the list) the hypereutectoid steels C_5, C_6, C_7 and the extra hard chromium steel S_3 which, as shown above, also have the best efficiency when working cold.

Taking all three above classifications together, the author establishes a general classification for high carbon and special steels which shows that chromium and tungsten steels generally do not stand well successive heatings and temperings, and that, unless the operations are well conducted, are liable to suffer. High carbon steels (with carbon content in excess of 1.15 per cent) require to be treated with great care and are generally quite sensitive to tempering; the hardness (as well as resilience, but in a lesser degree) of a large number of steels varied quite noticeably with the temperature of tempering and annealing, and it is absolutely necessary to use in their tempering the best temperature corresponding to the particular use to which they are going to be applied (*type-treatment*). In places where complete equipment for tempering, such as special furnaces, pirometers, etc., is available, chromium, tungsten and high carbon steels are preferably to be used, but where only simpler and cruder equipment is available, hard chromium steel and hypereutectoid carbon steels are preferable.

Power Transmission

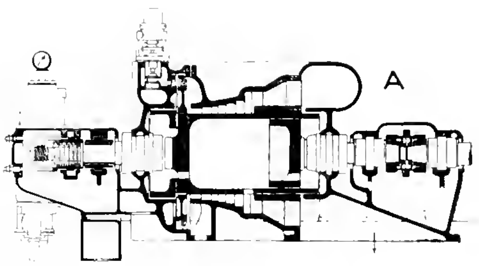
Power Transmission Losses and Stresses in Belt and Rope Drives (*Die Übertragungsverluste und die Beanspruchungen der Seil- und Riementriebe,* K. Kutzbach, *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 25, p. 1006, June 20, 1914, 6 pp., 8 figs. *te*). The author investigates the losses occurring in transmission of power by rope and belt drives and the stresses occurring in these transmission elements. He explains the distinctive features of the rope and belt drives by the elastic properties of these materials. Their common property of increasing the efficiency with the increase of useful tension, holds as long as the absolute losses remain more or less independent of the useful tension. In

the case of ropes, low elasticity and the unavoidable variation in length, far more than strength, limit their practically permissible tension, and consequently the efficiency of rope drive, which, from a practical standpoint, is not always the deciding argument. The author investigates graphically the action of centrifugal force in the case of belt and rope drives and the nature of what is known as "excess stress," as well as the distribution of stresses while the drive is in operation; by means of tension diagrams he shows why vertical rope drives are so difficult to install and so little reliable unless the ropes used are of particularly great elasticity. But even if such ropes were available, they would not be better than a rope drive having an axial stress of 30 to 40 kg/qcm. Rope drives working at high stresses always provide a stiff transmission, and the softness and elasticity of a leather belt transmission can be obtained in the case of rope drives only when the stresses in the rope are low. If in an installation involving a considerable amount of nonuniform drive or shocks, say an electric motor, a particularly soft transmission is required, nothing better can be devised than a really elastic and long leather belt connecting large masses at both pulleys. In such a case all the irregularities of operation and shocks will be taken up by the spring action of the belt, while in the case of rope it will be the transmission apparatus that will have to take them up. This will result in unpleasant knocking of the loose drums which is entirely avoided when belts are used. As far as efficiency alone is concerned, the steel belt is at the top of all other belts or rope methods of transmission, but owing to its very high coefficient of elasticity and the low influence of the action of its own weight for short distances, it gives a drive which connects the two wheels not elastically, but rigidly.

Steam Engineering

NOVELTIES IN THE DESIGN OF BROWN-BOVERI-PARSONS TURBINES (*Neuerungen im Bau Brown, Boveri-Parsons Turbinen. Zeits. für das gesamte Turbinenwesen,* vol. 11, no. 16, June 10, 1914, p. 253, 2 pp., 3 figs. *d*). The article describes the recent development in the design of the Brown, Boveri-Parsons steam turbines. The tendency is towards making the turbine more compact which is facilitated by the new materials of high resistance to stresses which have recently appeared on the market. The general design of the turbine (compare Fig. 8A) has remained unaltered with the following improvements, however: In order to reduce the amount of steam flowing through the dummy piston, the arrangement of equalization has been changed. It has formerly been usual to have one dummy piston at the high-pressure end and another at the low-pressure end, and to lead the "loss" steam from the high pressure and dummy piston direct into the exhaust of the turbine. Now, however, this steam is passed through the hollow shaft into the stage between the intermediate and low-pressures, and is therefore enabled to do the work in the low-pressure stage. By means of a small increase in diameter it proved also possible to obtain a little freer working of the dummy piston. An improvement in the construction of collar thrust bearings has made it recently possible to omit the dummy piston at the low-pressure end entirely and in this way to improve considerably the steam consumption.

In order to utilize fully the steam pressure at various loads on the turbine and avoid uneconomic throttling, the nozzles have been distributed into several groups; the first group, Fig. B, is directly under the action of the main regulating valve W, while the following groups, the number of which depends on the size of the engine, are regulated by one to four additional valves operated by oil under pressure. At small loads, only the nozzles regulated by the valve W are opened. When the load increases, the pressure behind these nozzles increases also and simultaneously the oil pressure under the piston Y increases so that when the steam pressure at the nozzles has approximately reached the boiler



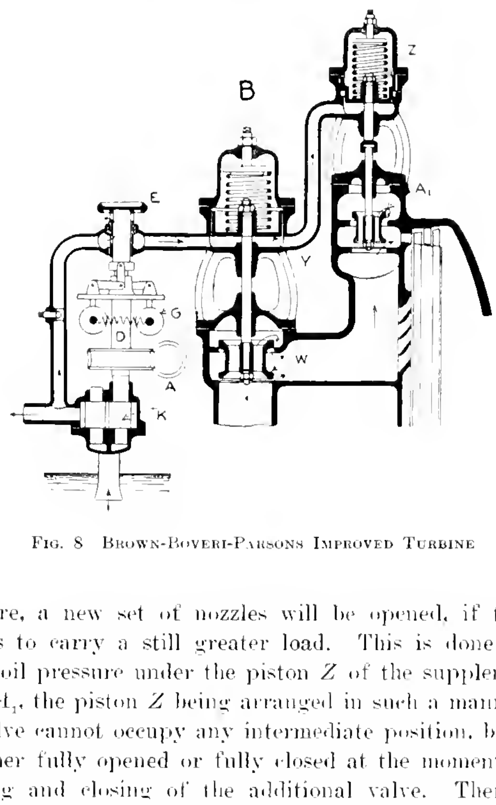


FIG. 8 BROWN-BOVERI-PARSONS IMPROVED TURBINE

pressure, a new set of nozzles will be opened, if the turbine is to carry a still greater load. This is done by the rising oil pressure under the piston Z of the supplementary valve A_1, the piston Z being arranged in such a manner that the valve cannot occupy any intermediate position, but must be either fully opened or fully closed at the moment of the opening and closing of the additional valve. There must be, however, some supplementary regulation of the main valve W, if there are several supplementary valves. The springs of the oil piston Z must be graduated in such a manner that the next valve will open only after the oil pressure has risen to the required extent; that is, when the steam pressure in front of the valve has reached nearly the level of the boiler pressure. The regulation proper is always carried on by the main regulating valve W, which, owing to the peculiar shape of the sleeve, is all the time in an oscillating motion and peculiarly adapted to respond to the slightest variations of the speed of rotation. Further information about the action of this apparatus is promised in a future issue of the paper.

Strength of Materials

Compression Tests on Cement Cubes (*Druckversuche mit Betonwürfeln*, Otto Graf, *Armierter Beton*, vol. 7, no. 6, June 1914 (article not finished) (e.1). The present article gives a compilation of results obtained at the laboratory for testing materials at the Royal Technical High School in Stuttgart from tests on the strength of cement cubes. The tests have been carried out for a number of years and the article gives a fairly complete account of the results obtained. On account of lack of space only the final conclusions will be reported here.

As regards the relation between the size of the body and its compression strength, it was found that cement bodies having a cross section of 180 qcm exhibited a considerably lower compressive strength than cubes with cross section of 50 qcm. It appears that the strength of a cube is a function of its age, and also that the ratio between the size and compressive strength of a cement cube is affected by the amount of water used in the preparation of the cement. Increase in the length of time of mixing produced a slight improvement in strength. As regards the relation between the amount of water used and the compression strength, the tests indicate that the older the test piece the less its strength is affected by the amount of water used. On the other hand, the influence of the amount of water used is but little affected by the cement test piece being kept in dry or moist atmosphere.

ENGINEERING SOCIETIES

FRANKLIN INSTITUTE

Journal, vol. 178, no. 1, July 1914, Philadelphia, Pa.

Locomotive Superheaters and their Performance, C. D. Young (abstract)

An Apparatus for the Spectroscopic Synthesis of Color, Herbert E. Ives and E. J. Brady

The Problem of Motor Gasoline, John Winkler

Locomotive Superheaters and their Performance, C. D. Young (83 pp., 56 figs. he.1). The article may be divided into two parts: the first containing a historical sketch of the construction of superheaters, and the second, data of tests performed at the Altoona shops of the Pennsylvania Railroad Company. On account of lack of space only the second part of this interesting article is reported here. The data of tests are presented partly in the form of curves and partly as tables. The superheater used for the tests was a Schmidt superheater of the fire-tube type or an altered form of it, consisting of tubes arranged in groups or elements and located in the large flues in the boiler. It was arranged in such a way that the steam from the boiler entered the header in the smoke box, then flowed into one of each of the superheater elements, passing twice through the hot gases which surrounded the element, and then directly to the cylinders. In order to obtain different degrees of superheat without in any way changing the water heating surface of the boiler or the engine conditions, different forms of superheater elements were used with the same superheater header and large flues. The various superheater elements and their sizes are shown in the original article. The locomotive used for all of the superheater tests was a class *K2sa* Pacific type passenger locomotive of the Pennsylvania Railroad Company with brick arch in the firebox. A complete efficiency test of this locomotive, equipped with the standard form of the Schmidt superheater, was made before the special superheater tests were undertaken (the results are given in full in Bulletin No. 18, issued by the Pennsylvania Railroad Company).

The results of tests refer to the following subjects: *Effect of different degrees of superheat*, tests made with small superheaters, superheaters of 1/4, 1/2 and 3/4 length. The small superheater tests gave an evaporation of about 31,000 lb. of water per hr., with an indicated horsepower of 1425, while with the same cut-off and an extra length superheater, the evaporation was only about 21,000 lb. for the same indicated horsepower, this effect being caused by the small superheat obtained with the short returns which require a great weight of steam for the power produced. It was found further that the small superheater would evaporate only 70 per

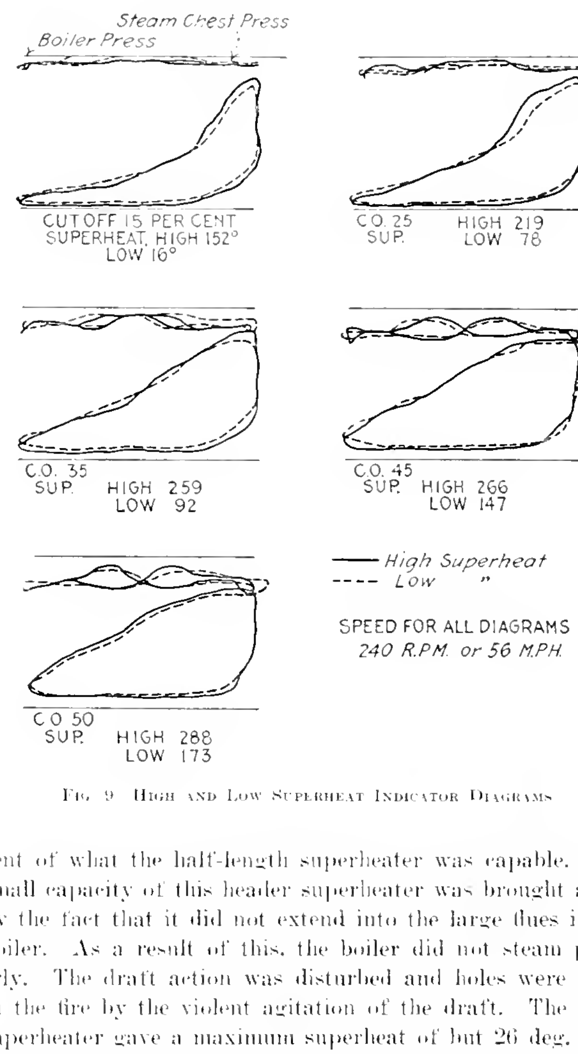


Fig. 9 High and Low Superheat Indicator Diagrams

cent of what the half-length superheater was capable. The small capacity of this header superheater was brought about by the fact that it did not extend into the large flues in the boiler. As a result of this, the boiler did not steam properly. The draft action was disturbed and holes were made in the fire by the violent agitation of the draft. The small superheater gave a maximum superheat of but 26 deg. The superheaters of 1/4, 1/2 and 3/4 length showed a regular increase in superheat produced with the increase in length of superheater. Further, as superheat was increased, the evaporation when running at a short cut-off was decreased; the one half length superheater gave a greater evaporation than was obtained with any other, namely, about 55,000 lb. per hr. It must not be understood, however, that this superheater, which is best for evaporation, gives the maximum horsepower. The extra length shows a higher superheat than standard length, but there might be difficulties in its use where the ends come within a few inches of the fire-box and of the flue. The standard half-return type gives fully

as much superheat. As regards the relation between cut-off and superheat, it appeared that the superheaters ranged in this respect in very nearly the same way as in regard to length of superheater and amount of evaporation, which might be expected since, on account of the constant speed, the evaporation was almost entirely a function of the length of cut-off.

Considering the economy resulting from the superheat, it appeared that at the shorter cut-offs there was a uniform decrease in the water rate with each increase in superheat. As the cut-off was extended, the water rate increased but had a tendency to become more nearly constant with an increase in superheat. A water rate of 24 lb. was obtained with the superheat of about 30 deg., but if the superheat was increased to 220 deg. without a change in cut-off, the water rate was reduced to 16 lb. From the table given in the original article, it appeared that at 15 per cent cut off, at the speed all the tests were made, for every 20 deg. rise in superheat there was a reduction in water rate of 1 lb. per indicated h.p-hr. At 50 per cent cut-off, this changed to a requirement of about 40 deg. rise for the same reduction in water weight. It appeared further that superheat always showed a saving in steam if the cut-off did not exceed 50 per cent. A further diagram shows that every increase in superheat resulted in a saving of coal per h.p-hr.

The article gives also data on temperatures in the boiler tube and superheater flue. It appears that there was a loss in steam pressure as the steam flowed from the boiler through the superheater to the steam chest. The superheater equipped with spiral blades in the tubes showed the largest loss in steam pressure as the steam flowed through the superheater. These blades had a retarding effect and the increasing superheat obtained by their use did not compensate for the loss of power due to the pressure fall. The short returns showed the least drop in pressure while the single-pass superheater showed a little greater drop in pressure. The diagrams for high and low superheat given in Fig. 9 indicated that there was a drop in pressure between the boiler and steam chests of about 8 lb. During the admission to the cylinder the steam having a low superheat showed loss in pressure throughout, but during expansion the pressure for the low superheated steam was higher than for the highly superheated steam. During the return stroke of the piston the steam having a low superheat showed a higher back pressure than the highly superheated steam. This indicated that the highly superheated steam was more fluid or flowed more freely into and out of the cylinder than did the steam of low superheat.

The results of the tests showed conclusively that there was an almost direct relationship between the economy in water and fuel and the degree of superheat. If the superheat at a short cut-off could be obtained as high as that which was obtained for a long cut-off, no doubt more remarkable economies would have been possible in steam per indicated h.p-hr. The other deductions which may be drawn from these tests were summarized by the author as follows:

(a) The standard superheater now in general use is found to give very satisfactory results with a possibility that some of the return portion could be eliminated with no detriment to the superheat obtained, and with an advantage in cost of material.

(b) Too much importance cannot be attached to the length of superheater; it must extend as far toward the fire as practicable limitations will allow, considering the life of the elements in the hot gases.

(c) There is an advantage in the return portion of the superheater, but this part may be shortened; to what extent has not yet been finally determined.

(d) As the superheat is reduced, the evaporation of the boiler is increased within certain limits; in other words, a boiler without superheater shows a larger maximum evaporation than one with a superheater. The power of the locomotive, however, does not increase with the greater weight of steam produced; on the contrary, the power is reduced with the reduction in superheat.

(e) Within the limitations of these tests, the highest superheat does not result in the lowest water rate; this is on account of the fact that to obtain the highest superheat the locomotive may be run at an excessively long cut-off, the long cut-off increasing the water rate to a greater extent than is compensated for by the increase in superheat.

INSTITUTE OF MARINE ENGINEERS

Transactions, Session 1914-1915, June 1914. Stratford.

Wood Charcoal, its Manufacture and Uses, W. D. Ashton Bost (abstracted).

Board of Trade Report on Explosion from a Boiler Stop Valve Chest.

Wood Charcoal, its Manufacture and Uses, W. D. Ashton Bost (33 p. *gp*). The article discusses mainly the uses of wood charcoal. The author states that "in America the output of charcoal iron is enormous, owing to the vast amount of cheap wood and the furnaces carbonizing it for themselves and recovering the products." Speaking of the use of charcoal for insulation, especially on ships, the author discusses the possible fire danger.

As regards the method of extinguishing flake charcoal, the author states that it is done by freely exposing it to the air; it was formerly supposed to be extinguished by absorbing oxygen in the process. This, however, is not correct, because, although flake charcoal does absorb all the oxygen it wants, this has nothing to do with the cooling which is effected by allowing it to give off all its heat while being tossed about. By exposing each particle to the air, the temperature of the coal is lowered after a certain number of such exposures. While lump wood charcoal takes 24 hr. to cool with exclusion of air, flake charcoal takes 10 min. when exposed to the air. In the well known tests of Dr. Rosenhain, it was found that the conditions necessary for firing charcoal were such as could not be found at sea except in the case of fire outside the charcoal setting it on fire. The only exception possible is the presence of sulphur dioxide. In Dr. Rosenhain's first experiment, the conditions were more severe than could occur in actual practice, for the charcoal was put loosely into a perforated box, surrounded on all sides by 3 in. of air free to move, whereas in practice the charcoal has air-tight casing. Even under these conditions the temperature was raised to 370 deg. cent. or nearly four times the temperature of boiling water without ignition taking place. It might however be said that while charcoal in the insulation is not liable to spontaneous combustion, yet it might help to propagate a fire.

The following figures from the Board of Trade reports on fires in British steamers of 100 tons and upwards for twelve

years, show that in proportion to the number of ships fitted with charcoal and silicate cotton respectively, there have been more fires in the latter than in the former. If instead of making the comparison between charcoal and silicate cotton, it is made between combustible and uncombustible insulating material, it would be found that in proportion to their numbers there have been more fires in the latter than in the former. It is further proved that a fire on a ship with combustible material is generally less serious in character than on one fitted with incombustible material, which is a somewhat startling fact.

SOCIETY OF ENGINEERS

THE UTILIZATION OF SOLAR ENERGY, A. S. E. Ackermann. (Abstracted from report published in *The Electrician*, April 17, 1914.) The paper was read before the Society of Engineers on April 6, 1914, and gave some hitherto unpublished data on the sun power plant as well as data on tests of the absorbers used in this plant. The latest pattern of the absorber gave a maximum thermal efficiency of no less than 40.7 per cent and a maximum output of steam of 1442 lb. per hr. at a pressure of 15.8 lb. per sq. in. absolute. This absorber consists of five sections, each 205 ft. long, 13 ft. 5 in. wide between the edges of the mirrors. The cross-section of each of the five sections is parabolic and the mirror portion may be described as five large parabolic channels. The sections are placed with their major axis north and south. To receive the morning sun they are heeled over to the east and move automatically very slowly from that position to the west so as to follow the sun. This automatic movement is controlled by a small and simple thermostat, consisting of three fingers, each made of a thin plate of brass underneath and a plate of vulcanite on top. The principle of working this thermostat is that two fingers are in the shade and the third in the sunshine. Should one of the outer fingers get off from the shade it is rapidly heated up by the sun, bends down, closes an electric circuit and starts a mechanism which moves the mirror. From the results of tests of various types of absorbers the author has derived a formula by means of which it is easy to calculate for a given type and size of absorber the total output of steam per hour, when three things are known: the time of day, the steam pressure and the humidity (humidity adversely affects the quantity of solar radiation arriving at the earth's solid surface). The author shows further that in the case of such low-pressure boilers, the high thermal efficiency is not necessary since, up to a certain point, the higher the steam pressure the more economical the working, although the thermal efficiency is then lower.

THE ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Proceedings, vol. 30, no. 1, February 1914. Pittsburg, Pa.

Discussion of Operating experiences with Steam Regenerators (abstracted)

Crucible Steel, George H. Neilson

TESTS OF STEAM REGENERATORS AND LOW PRESSURE TURBINES, FRANK E. LEAHY (39 pp., 6 *figs.* *e*). In a previous paper before the same Society, Mr. F. G. Gasche discussed the theory of steam accumulative and regenerative processes which prompted several engineers in the Western Pennsylvania district to make extensive tests with steam regenerators. Mr. Leahy made tests on a regenerative system located between a blooming mill and a slabbing mill in front of a low-pressure turbine station, consisting of three American steam regenerators connected in parallel and operating as a unit. Each regenerator consists of two steel tanks, one above the other, the lower being designated as the expansion chamber and the upper as the regenerative chamber. The operation of the regenerative system is as follows: the exhaust steam enters the lower tank and in passing into the spray-box strikes a vane, turning it through a certain angle, depending on the quantity of steam flowing. This movement is transmitted to the regulating water valve which admits the water to the spray-box. The greater the quantity of steam flowing, the greater the angle through which the vane turns and as a consequence the admission of water through the valve. The steam and water meet in the spray-box and the mixture passes through an ejection pipe into the upper tank, the water absorbing the heat from the steam on the way. In this manner the heat is stored in the upper tank and becomes available for use when required. If at any time the pressure in the top tank drops to sixteen lb. absolute, due to decrease in the supply of exhaust steam, the live steam reducing valve is automatically opened and admits steam to the lower tank, closing as soon as the pressure in the top tank increases to eighteen lb. absolute. If at any time there is such a surplus of exhaust steam that the pressure in the top tank exceeds nineteen lb. absolute, the relief valve opens, discharging the excess steam to the atmosphere. In order better to control the conditions of operation in the tests, live steam was used throttled through a reducing valve. The observations during the tests were taken as follows: The average temperature of the water in the regenerator by thermometers placed at various places in the tank; steam temperature by a thermometer placed in the top of the regenerator tank; pressure in the top and bottom tanks by mercury columns; height of water on both ends of the regenerative tanks by graduated water gage glasses.

The author presents the results of his tests in the form of tables (see Table 3). In addition to the tests of the regenerative equipment, tests of the turbo-generators were also made. The low-pressure turbine station consists of one Curtis low-pressure turbo-generator, one General Electric motor-generator set, one small General Electric turbo-generator, with d. c. for excitation, switchboard and a Weiss dry air pump. The low-pressure turbine is a Curtis horizontal, three-stage impulse type rated at 3000 kw., 1500 r.p.m., form *E*, designed to run condensing and deliver its rated capacity with an initial pressure of 16 lb. absolute. The turbine exhausts into a Weiss barometric counter current condenser of self supporting type and a rated capacity of condensing 150,000 lb. of steam per hour. The turbine tests were run to determine the steam consumption of the turbine at various loads. The net results obtained by the installation of the low-pressure turbine and regenerators were as follows:

First: An increase of 57.5 per cent in the rated electrical capacity of the plant.

Second: The back pressures, in pounds per square inch, on the blooming and slabbing engines were as follows:

	Operating Alone		Operating Together		Before Turbine Installation	
Engines	Average	Maximum	Average	Maximum	Average	Maximum
Blooming Mill..	3.77	10.00	7.35	10.00	1.50	5.30
Slabbing Mill ..	5.04	10.06	7.82	11.00	1.10	6.20

Third: The load on the turbine is such that the steam consumption of the turbine is practically constant. When only the blooming engine is operating, the supply of exhaust steam, which is approximately 76,000 lb. per hour, is insufficient to meet the demands of the turbine and in order to provide this deficiency, the live steam valve is open about 10.5 minutes per hour. When only the slabbing mill engines are operating, live steam is admitted to the turbine about 2.6 minutes per hour, exhaust steam from these engines being approximately 100,000 lb. per hour. In either of the above cases it is very seldom that any exhaust steam escapes to the atmosphere. When both mills are operating at the same time, the exhaust steam is much in excess of the demand, and the relief valves are open about 18.9 minutes per hour, discharging the excess steam to the atmosphere.

Operating difficulties: When the low-pressure turbine and regenerators were first put into service a good deal of trouble was experienced with the reducing valves. This being a straight low pressure turbine it is imperative that the reducing valves be absolutely reliable and positive in their performance. The first valve used was a 12 in. Foster reducing valve designed to open at 15 lb. and close at 15.5 lb. absolute pressure, but it proved not to be well adapted to this kind of service and better results were later obtained by the use of a balanced piston valve which is positive in its action, being controlled directly by the pressure in the regenerators. This valve has been in operation since July 1912 and has given complete satisfaction. Another source of trouble was due to the imperfection in the design of the pilot valve which operated the water mixing valve. It would find a position of admission and exit that would give to the piston of the operating cylinder a violent reciprocating motion, either breaking the valve steam or causing the valve to sit hard enough to break the body of it. A change in the design of the piston and ports was made which eliminated this trouble. The article contains very complete data of the tests.

Experiments with a Small Steam Regenerator, C. L. W. Trinks (6 pp., 4 figs. *e*). The experiments made by the author included tests on an experimental regenerator made of 20 in. pipe and experiments on absorption of jets of steam in a specially constructed glass vessel. The author found that the results obtained from the former were not applicable to apparatus of commercial size. In the experiments with the glass container, conditions were maintained such that the temperature, pressure and water level were kept constant. Steam was added in such quantities that all of it was just absorbed at the surface of the water, thus representing the limit of total steam absorption for the given discharge orifice, temperature difference and depth of immersion. At first a single jet of steam was used, and its shape proved to be different from what might have been expected. Instead of there being a number of bubbles rising through the water, the jet expanded to at least four times the size of the pipe opening and looked very much like an unsteady flickering flame, the top of which was darting hithr and thither (Fig. 10A). Spreading of the steam jet was probably due to the resistance which it found against the water in trying to rise. A small box was next used resembling a section of a regenerator element. It was discovered that the steam coming out of the lateral holes spread to such an extent that the steam jets interfered with each other. It was also discovered that the kinetic energy of the flow of steam was excessively large as compared with the discharge capacity of the bottom openings. A special baffle was then provided to produce induced circulation. The left hand part of Fig. B shows approximately the appearance of the steam jets essentially different from that shown in the catalogue of the Rateau Regenerator Company. Fig. C shows that complete steam absorption with small temperature difference necessitates a very slow rate of flow of steam and discharge through the upper row of holes only. If complete absorption of steam and discharge through several rows of holes is wanted, the temperature difference between the steam and water must be quite excessive. The author gives the following brief calculation; with permissible temperature difference and for complete ab-

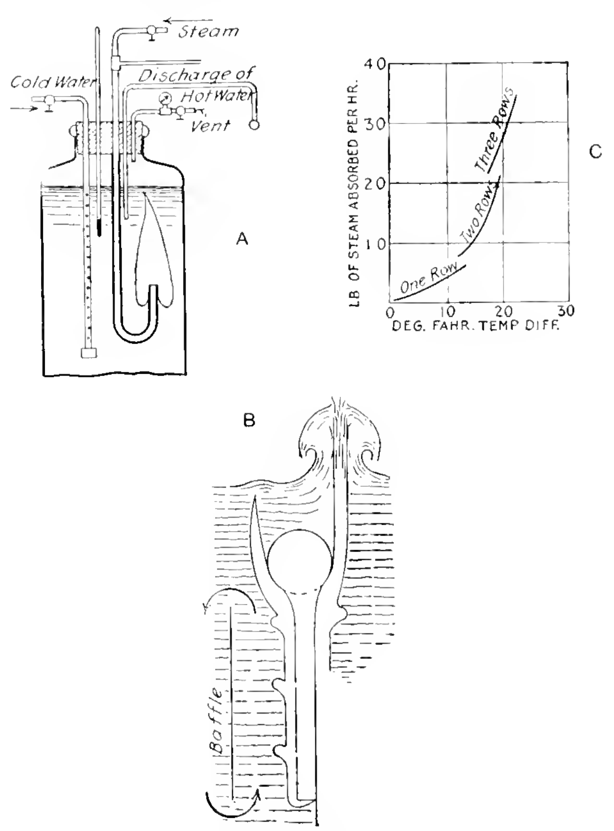


Fig. 10 A and B, Spread of Jet in Small Steam Regenerators; C, Steam Absorption in Regenerators

sorption of steam, a horizontal length of absorbing surface of about three miles will be necessary for an ordinary 55 x 60 reversing engine doing medium, heavy work at 60 r.p.m. This figure is based on 15 deg. fahr. temperature difference and a 4-in. depth of immersion. If three regenerators were used, each with four absorbing surfaces, and if the depth of immersion be increased to ten inches, then the length of the regenerator could be reduced to 500 ft. This appears to show that regenerators as designed now cannot absorb all of the steam which comes from a reversing mill engine unless the temperature difference is excessive.

The author believes that all absorption regenerators would have to be redesigned in the shape of multiple flat boxes with considerably less depth of immersion and only one row of holes, which would make them too costly for commercial

TABLE 3 SUMMARY OF TESTS MADE ON REGENERATOR (NO. 2) AT TURBINE STATION
REGENERATIVE PERIOD

Test No.	Tank No.	V Cu. Ft	W Lb.	m Lb.	t_3 Deg. F.	t_2 Deg. F.	t_1 Deg. F.	θ (t_3 to t_2) Sec.	θ Sec.	Q Actual Heat Storage	Q Theoretical Heat Capacity	Efficiency Per Cent
1	2	896	93,909	567	222.3	216.0	205.0	1.00	88.2	1,045,800	1,637,280	63.8
2	2	991	88,200	567	225.1	216.2	206.5	1.85	77.3	871,257	1,656,237	52.6
3	2	991	88,178	567	227.1	219.3	206.3	2.08	101.8	1,164,132	1,851,920	62.8
4	2	893	94,374	567	225.0	214.2	195.2	3.21	162.8	1,814,245	2,833,384	64.0
5	2	970	89,363	567	227.2	219.8	210.3	1.89	77.4	863,653	1,524,939	56.6
6	2	979	89,292	567	225.3	212.8	195.0	1.87	150.0	1,612,865	2,729,013	59.1

V volume of receiver spaces, cu. ft.; W weight of heat absorbing water lb.; m pounds of steam per minute from the regenerator; t_3 temperature of steam entering the regenerator, deg. fahr.; t_2 final temperature of absorbing water, deg. fahr.; t_1 initial temperature of absorbing water, deg. fahr.; θ (t_3 to t_2) time in seconds for receiver expansion from t_3 to t_2; θ (t_2 to t_1) time in seconds for regenerator expansion from t_2 to t_1.

purposes. Further experiments have shown that with the comparatively small quantity of steam passing unabsorbed, the rate of steam absorption could be vastly increased. There is, therefore, no well defined limit to the steam absorption; with increased flow more is absorbed, but the water is lifted so high and the steam passing through entrains so much water that the operation of the turbine becomes dangerous. A considerable amount of interesting material which cannot be abstracted on account of lack of space is contained in the discussion which followed the presentation of these papers.

Notes on Specifications for Regenerators, O. P. Hood (7 pp., 2 figs., *ep*). As a result of some experience in testing a regenerator installation, the author discusses the wording of a contract for this class of apparatus. One of the problems in establishing the specifications for regenerators is that of defining its capacity. A definition, "the capacity of the regenerator plant shall be sufficient to handle the maximum hourly rate of delivery (of exhaust steam) to the best practical advantage," is entirely too indefinite to insure a device that would use a fair proportion of the waste product and at the same time not interfere with the functions of the engine. A better statement would be, "the regenerator will be of sufficient size to operate a turbine unit of the given capacity for a period of five minutes after the supply of steam is shut off," but some provision in such a case has to be made as to how long previous to the shut off the supply of steam shall be maintained. A statement of the following kind "provided the supply has been maintained for a sufficient time to provide as many heat units as the containing water will absorb at the operating pressure" is rather unfair to the buyer of the apparatus since whether the device is efficient in absorbing heat or not, the wording demands that steam shall be supplied until the absorption is complete. In the contract which the author had especially in view, it was further stipulated that "an automatic release valve will be provided to allow a free escape of the steam when the pressure exceeds one pound above the present exhaust pressure." It is evidently to the advantage of the regenerator to have as wide a range of pressure as possible. Running the pressure below an atmosphere on a hoisting engine may be objectionable and the lower regenerator pressure was therefore limited approximately to atmospheric pressure. The superior pressure allowed on the regenerator adds to the back pressure on the engine and this addition increases its normal steam consumption and it is between these narrow limits of pressure that the regenerator must run. With increasing back pressure there comes a condition when the saving at the exhaust end of the operation is more than offset by the cost of the added steam needed by the main engine and the added auxiliaries. This is one of the reasons why some plants of this kind, although returning a product from exhaust steam, are unable to drop any boiler capacity as a result of the installation. In testing the plant it was found that the apparently simple condition of the contract that there should be "a free escape of steam when the pressure exceeds one pound above the present exhaust pressure" proved to be far from simple in determination since it made it necessary to determine what the old back pressure was. As the author states, there may be a very honest difference of opinion as to the meaning of the phrase "back pressure" and also several poor ways of determining what it is. Some of these poor ways the author describes. The most satisfactory method of determining the back pressure would be to take continuous indicator diagrams of the open type, using a light spring arranged with a positive stop so that pressures beyond the range of the spring would not injure it. The average back pressure for each stroke of the cycle could then be plotted as an ordinate with the number of the stroke as a base, thus giving a curve representing the many back pressures through the cycle. Such curves obtained under different conditions would be comparable and the pressure range allowed between them could be a definite matter of contract. This method, however, requires special indicators which are by no means common. It would, therefore, seem to be desirable that in specifications for regenerator installations the method of determining the back pressure from the engines should be a part of the contract as well as the allowed addition of pressure imposed by the regenerator. It is also desirable when applied to the exhaust of a hoist or similar engine, that the regenerator pressure be automatically adjusted according to the load on the turbine, if this is a variable. Although great savings can be made by the use of regenerators attached to hoisting engines, it only takes small additions of back pressure in connection with regenerators of insufficient capacity to change an apparent saving at the exhaust into an actual loss at the coal pile.

PERSONAL NOTES

Charles L. Pillsbury has recently been engaged in two appraisal undertakings with Prof. E. W. Bemis of Chicago, with whom Mr. Pillsbury worked on the Minneapolis gas appraisal, one of these at Washington, where Mr. Pillsbury is acting as chief engineer in charge of the appraisal of all public utilities of the District of Columbia, and the other in Detroit, where the street railway properties are being appraised.

J. R. Bibbins of Chicago has been engaged by the law department of the City of Pittsburgh in an advisory capacity in connection with proceedings for the improvement of local transportation conditions in that city. This work has the support of the city administration and through coöperative study of the various phases of the problem with the Railways Company an attempt will be made for an operative service standard, for scientific re-routing in the terminal district, and for progressive rehabilitation of the property until adequate physical condition is reached. The matter will then be referred to the Public Service Commission.

Thomas H. Mirkil, Jr., has resigned as vice-president and general manager of the Poole Engineering & Machine Company, Baltimore, and is now resident manager of the Treadwell Engineering Company of Easton, Pa., with an office at 1011 Chestnut Street, Philadelphia.

Chas. S. Mott, president of the Weston Mott Company, Flint, Mich., and ex-mayor of that city, was recently tendered a dinner in celebration of his return from a trip abroad, by men who had been intimately associated with Mr. Mott in the development of local industrial enterprises. The speakers called attention to Mr. Mott's efforts in the direction of city betterment and his insistence upon the application of business principles in municipal affairs.

Ralph W. Deacon has been appointed superintendent of the U. S. Metals Refining Company, Chrome, N. J. He was formerly associated with the British America Nickel Corporation, Ltd., Nickelton, Canada, as metallurgical superintendent.

William H. Smead has severed his relations with The Samuel Austin & Son Company, Cleveland, Ohio, as manager of the heating and equipment department, and has opened an engineering office in Cleveland, Ohio, making a specialty of forced hot water heating systems and power house plants.

David C. Fenner has become affiliated with the General Vehicle Company, Inc., New York. He was until recently in the employ of the International Motor Company, New York.

Jay W. Skinkle, who has been associated with the Western Electric Company, Chicago, Ill., for the past 15 years, during the last six of which he has been in charge of the manufacturing methods department, has been transferred to the European organization of the company and sails for London on August 1. Mr. Skinkle's work will be on the manufacturing staff with headquarters at the company's factory at North Woolwich, London, and his duties will require frequent visits to the manufacturing plants of the Western Electric Company, of which there are several in the principal cities of Europe.

Walter N. Polakov, formerly consulting engineer with Day & Zimmermann of Philadelphia, Pa., is now associated with The New York, New Haven & Hartford Railroad Company, as superintendent of power.

Frederick O. Ball has resigned as general manager of the American Engine and Electric Company of Bound Brook, N. J., and will engage in the manufacture and sale of carburetors with his father, Frank H. Ball, who retired from the engine business last year. The carburetor business will be conducted under the firm name of Ball & Ball, with headquarters in Detroit, Mich.

Dwight O. Barrett has accepted the position of superintendent of the Charles City Engine Company, Charles City, Ia. He was formerly affiliated with the Heer Engine Company, Portsmouth, Ia., in the same capacity.

Gerald E. Terwilliger has terminated his association with Messrs. Davis, Donohue, Thompson & Deitz, and will continue the practice of patent trade-mark and copyright law at 50 Church St., New York, in association with Clifford E. Dunn.

Harry J. Klotz has resigned his position as assistant in mechanical engineering at Rensselaer Polytechnic Institute, Troy, N. Y., and has accepted a position in the operating engineering department of the Illinois Traction System, Peoria, Ill.

William Fowden, recently superintendent of the U. S. Portland Cement Company, Concrete, Colo., has become connected with the Dewey Portland Cement Company, Dewey, Okla., in the same capacity.

Allen V. Moyer has accepted the position of mechanical engineer with the George T. Ladd Company, Pittsburgh, Pa. He was formerly associated with the Heine Safety Boiler Company of Phoenixville, Pa.

N. N. Williams has become a Junior Member of the firm of E. T. Archer & Company of Kansas City, Mo. He was until recently affiliated with the Harrisburg Light & Power Company, Harrisburg, Pa., as mechanical engineer.

James U. Norris, formerly connected with the Rockefeller Institute for Medical Research, New York, as assistant manager, has accepted the position of superintendent of the New York Polyclinic Medical School and Hospital, New York.

EMPLOYMENT BULLETIN

Note: In sending applications stamps should be enclosed for forwarding.

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

POSITIONS AVAILABLE

608 Engineer or draftsman with wide experience in the construction and design of steel cars for elevated and underground railroads, wanted for employment in car factory in Germany; traveling expenses paid, and only slight knowledge of German language required. State salary expected.

611 Salesman for Eastern States, for thermo-dynamic apparatus as full line of condensers, recooling apparatus, feed water heaters, air and oil coolers, air heaters, air filters and washers for generators. Location Boston.

701 Young engineer, technical training with experience in devising methods of reducing costs in a machine shop building medium and heavy machinery. Knowledge of pumping machinery desirable, but not necessary. Must be tactful and have ability to exhaust the possibilities of cost reduction with present equipment before suggesting purchase of new. Apply by letter.

703 Foreman, between 33 and 42 years of age, for machine shop, employing normally about sixty men, and manufacturing heavy special machine tools for use in works, also manufactured products entering into the sales product. Salary will be fixed according to ability, experience and possible competency for other position in the organization of the company. Apply by letter. State age, detail of schooling and previous experience.

704 Engineer salesman for Chicago territory, for thermodynamic apparatus, such as full line of condensers, recool-

ing apparatus, feed water heaters, oil and air coolers, air heaters, air filters and turbo-generators.

705 Young man of analytic turn of mind and with gift of "trading marbles" wanted in sales department for paper mill lines of middle west concern. Apply by letter.

706 Cost man to have actual charge of time and as assistant to superintendent of concern in middle west, manufacturing power pumps and paper mill machinery. Apply by letter.

707 Man to take charge of designing and engineering work of railroad motor cars and some kindred lines. Would prefer one who has had some experience in railroad work. Location Michigan.

709 Representation wanted, notably in Philadelphia, Pittsburg, St. Louis, Kansas City and Omaha, by mechanical engineers who are established with their own offices and will be able to take up the handling of the "Productograph."

713 Graduate engineer to take responsible charge in the field of a modern steam shovel plant, consisting of shovels, locomotives, cars, etc., of company operating in anthracite coal region. Applicant must have some experience with steam shovels, familiarity with their mechanism and capabilities. Present salary $200 per month.

MEN AVAILABLE

H-800 Member, technical graduate, desires position as chief draftsman, mechanical engineer, or designer of steam pumps, simplex or duplex; several years experience designing, testing and erecting. At present employed.

H-801 Superintendent capable of handling large machine shops, foundries and manufacturing plants; wide experience on high grade work, good executive, has organized and completely equipped large modern shops.

H-802 Mechanical engineer, Junior, thoroughly familiar with machine tools and specialties, bridge, structural and pipe contract work desires commission agencies. Located on the Pacific coast.

H-803 Graduate mechanical engineer, two years outside experience of varied nature, desires position as instructor; prefers laboratory or steam power plant work. Can furnish best references.

H-804 Technical graduate in mechanical and electrical engineering, six years shop experience and four years as traveling salesman, desires to represent a first class company in Philadelphia or vicinity as manufacturers' agent.

H-805 Member, technical graduate, age 35, wide experience in design and application of steam and compressed air machinery, at present engaged in successful independent consulting practice, would consider regular employment with a view to permanent association with an aggressive and responsible concern; would qualify as engineer in purchasing or plant departments of industrial or mining properties.

H-806 Member, graduate M.E., over 25 years experience in his line, owing to slightly defective hearing, wishes to change to a field of work in which this will not be a hindrance to efficiency and advancement, as research, experiment, testing, inventions, patents, designs, development work, examinations, investigations, reports, office or field, or with consulting engineer, company or corporation.

H-807 Junior, wide experience in steam turbine power plants, electric railway and lighting properties, eliminating operating difficulties, reducing costs, securing new business in positions of chief and electrical engineer, desires position as salesman of electrical or steam equipment. Prefers position in Middle States or Middle West; no objection to traveling.

H-808 Purdue University graduate, '03, who has for several years specialized on research and development work, desires position with firm requiring investigation of engines, machinery or materials of construction.

H-809 Member, technical graduate, age 33, experienced as chief draftsman and as manager of engineering and drafting departments in manufacturing lines, desires position as mechanical engineer or assistant to superintendent or manager.

H-810 Member, age 30, technical graduate in mechanical engineering, seven years practical experience in engine and heavy machinery design, desires position of responsibility with progressive concern or consulting engineers engaged in the manufacture of prime movers and heavy machinery, or designing, construction and operation of power plants. Salary $200-$225.

H-811 Member, M. I. T. graduate, age 40, eight years experience structural design and as superintendent, eleven years varied and valuable experience in mechanical design and manufacture, including four years in turbine design, specialty of stresses and smaller mechanisms, desires position where this experience can be applied. At present, safety assistant for large corporation. New England location preferred.

H-812 Mechanical engineer, technical graduate, age 30, desires responsible position. Thorough knowledge of all types of pumps and pumping machinery, gasoline and oil engines, steam engines and sugar house machinery, also drawing room, erection room and engineering department experience in large pump manufacturing company; sugar plantation work in Mexico and sales engineer in Brazil.

H-813 Member, technical graduate, age 33, ten years experience in light metal manufacturing and foundry work; thoroughly familiar with modern and economic methods of shop management, seeks position as superintendent, preferably with large company. Salary $5000. At present employed.

H-814 Junior, age 38, sales engineer, experienced in handling high-grade power transmission and mechanical specialties, desires to represent manufacturer. Eastern or middle west preferred.

H-815 Junior, age 23, graduate mechanical engineer of Columbia University, one year practical experience, desires position as assistant to manager or superintendent in industrial concern. Location immaterial.

H-816 Junior, age 31, married, 12 years experience heating and ventilating, estimating, drafting and machine design, five years residential engineer for well known company, executive ability, capable of taking entire charge of design and specifications for heating and power plants, purchasing of equipment and materials, desires position with reliable concern or consulting engineer with chances for advancement. At present employed.

H-817 Mechanical engineer, technical graduate, 15 years shop and mill experience, desires important position as plant engineer, or would consider taking an interest with services in small manufacturing enterprise turning out mechanical goods.

H-818 Member, technical graduate, age 32, nine years experience in design and testing of steam turbines and centrifugal air compressors, including blast furnace compressors, desires a position where this experience will be of value; unusual experience in turbine research work, during last three years has determined the leading dimensions and tested a complete line of turbines 100 to 2500 kw. capacity.

H-819 Mechanical engineer, ten years experience with responsible firms in hoisting and conveying machinery, cement plants, general manufacturing and maintenance, office, shop and field.

H-820 Cornell graduate, 28, married, seven years experience as machinist, tool maker and master mechanic, desires

position teaching experimental engineering, mechanics or physics in or near New York. At present employed.

H-821 Member, mechanical engineer, age 38, married, 11 years experience in design, construction and operation, wishes position with cement manufacturing company with chances of advancement; recently superintendent of a large plant; salary moderate.

H-822 Member, graduate M. E., 15 years experience, seven years in connection with manufacture and sale of medium and heavy weight machinery as responsible executive assistant to high officials; duties have included pushing out products, systematization, analysis of costs, short cut estimates, general office management and sales; interested in similar position or one connected with manufacturing or sales department exclusively.

H-823 Member, wide experience in shop and office, five years confidential aid to consulting engineer, having general charge of drafting room and design of railway and lighting power plants, special apparatus, etc., handling reports, specifications and correspondence, wants responsible position as engineer with operating company, manufacturing concern or consulting engineer.

H-824 Junior, age 27, technical graduate, five years experience in automobile factory building high priced cars, desires position as assistant superintendent or manager.

H-825 Member, managing sales engineer, open for contract, has handled successfully well known accounts accepting all responsibility of the entire office; diplomatic and progressive, broad acquaintance in the manufacturing, engineering and contracting field. Location New York and East.

H-826 Member, graduate M. I. T. in mechanical engineering, post graduate course in electrical engineering, wide experience in design and construction of machinery and buildings, manufacturing, systematizing and accounting, desires permanent position in New York.

H-827 Member, age 40, 18 years engineering experience, six years of which have been buying and inspecting machinery and supplies, desires position as purchasing agent; have been buying at lowest prices for resale to largest consumers and can reduce costs.

H-828 Member, mechanical engineer, desires responsible position; 14 years experience in power plant work, heating, ventilating, mill engineering and factory; executive ability; best references.

H-829 Junior, age 27, graduate mechanical engineer, desires position with engineering firm or in industrial plant; four years experience in general plant work in design and construction of machinery and buildings; one year with boiler concern, also shop and testing experience. At present employed.

H-830 Student Member, 1914 M. E., graduate of middle west university, experience on practically every type of farm machinery, wishes position as apprentice or shop workman in factory that specializes in improved farm machinery.

H-831 Member, age 33, 11 years general experience in design and construction of mill buildings, furnaces, boiler, machinery and mechanical equipment of power plants, structures for conveying, elevating and storing coal, ores and other materials. Has acted as chief draftsman, superintendent of construction, mechanical engineering and manufacturing plants. Position desired along these lines; location immaterial but prefer middle West.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

Abhandlungen und Berichte über Technisches Schulwesen. Vol. 5. *Arbeiten auf dem Gebiete des Technischen Hochschulwesens. Berlin, 1914.* Gift of Verein deutscher Ingenieure.

Acht Vorlesungen über Theoretische Physik gehalten an der Columbia University in the City of New York im Frühjahr 1909, Max Planck. *Leipzig, 1910.*

American Association of Demurrage Officers. Proceedings of the 25th annual convention, 1914. *St. Louis, 1914.* Gift of Association.

American Manufacturers Export Association. Proceedings of 4th annual convention, 1913. *New York, 1913.* Gift of Association.

American Railway Association. Proceedings of session held in New York City, May 20, 1914. Gift of Association.

American Railway Engineering Association. Manual, 1911. *Chicago, 1911.*

American Society of Swedish Engineers. List of Members May 15, 1914. *Brooklyn, 1914.* Gift of Society.

American Water Works Association. Proceedings of the 33d annual convention, 1913. *Troy, 1913.* Gift of Association.

Atlantic Deeper Waterways Association. 6th annual convention, 1913. *Philadelphia, 1913.* Gift of Association.

Automatic Sprinkler Protection, Gorham Dana. *Boston, 1914.*

Boston Metropolitan Water and Sewerage Board. 13th annual report. *Boston, 1914.* Gift of the board.

Bridges of New York City, R. K. Thomson. Reprinted from *Engineering Magazine*, September-October, 1909. Gift of author.

Computations for Marine Engines, C. H. Peabody. *New York, 1913.*

Design and Construction of Oil Engines, with an appendix on marine oil engines, A. H. Goldingham. ed. 4. *New York, 1914.*

Dieselmotoren. A. Riedler. *Vienna, 1914.*

The Elasticity and Endurance of Steam Pipes. C. E. Stromeyer. *London, 1914.* Gift of Master Steam Users' Association.

Electric Touring, presenting a number of electric automobile tours in New York, New Jersey and Connecticut. New York Electric Vehicle Association. Gift of Association.

Engineers Handbook of tables, charts and data on the application of centrifugal fans and fan system and motors, air washers, hot blast heaters and systems of air distribution. Published by Buffalo Forge Company. *Buffalo, 1914.*

Entwerfen und Berechnen von Heizungs und Lüftungsanlagen, Otto Wieprecht. ed. 4. *Halle a S., 1910.*

Erecting and Operating: An educational treatise for constructing engineers, machinists, millwrights and master builders, William Rogers. *New York, 1913.*

Ergebniss der Beratungen des Deutschen Ausschusses für Technisches Schulwesen über Hochschulfragen. *Berlin, 1914.* Gift of Verein deutscher Ingenieure.

Fitting and Erecting of Engines, C. L. Browne. *Manchester, 1914.*

Foundations of Bridges and Buildings, H. S. Jacoby and R. P. Davis. *New York, 1914.*

Zur Geschichte der Drahtseilschwebebahnen, Franz M. Feldhaus. *Berlin, 1911.*

Handbuch der Ingenieurwissenschaften. pts. 3, 5. *Leipzig, 1914.*

Heat, E. M. Shealy. *New York, 1914.*

Hoisting Machinery for the Handling of Materials, T K. Thomson. Reprinted from Engineering Magazine. Gift of author.

Hydraulic Tables, G. S. Williams and Allen Hazen. ed. 2. *New York, 1911.*

Illinois Society of Engineers and Surveyors. Twenty-ninth annual report, 1914. *Wheaton, 1914.* Gift of the society.

Illinois Water Supply Association. Proceedings of 6th meeting, 1914. *Urbana, 1914.*

Insulated Return Feeder System for Mitigating Electrolysis Installed by the United Railways Company of St. Louis, Mo., in the Ann Avenue Substation District, Report on. May, 1914. Gift of S. S. Wyer.

International (15th) Congress on Hygiene and Demography. Washington, Sept. 23-28, 1912. Transactions. vol. 1, pt. 1-2; vol. 5, pts. 1-2; vol. 6. *Washington, 1913.*

Kondenswasser-Ableiter, Deutsche-Englische, Amerikanische. Praktische Ratschläge für Dampfkesselbesitzer. Robert Wagner. *Leipzig, 1911.*

Lectures Delivered at the Johns Hopkins University in May, 1914. L. G. McPherson. *Baltimore, 1914.*

Die Maschinen-elemente ihre berechnung und konstruktion, C. Bach. ed. 11, bd. 1. *Leipzig, 1913.*

Modern Packing House, F. W. Wilder. *Chicago, 1905. Gift of Hunt Memorial Fund.*

München-Technischen Hochschule. Bericht über das studienjahr, 1912-1913. *Munich, 1914.* Gift of Technischen Hochschule.

—— Program 1913-1914. *Munich, 1914.* Gift of Technischen Hochschule.

New Orleans Sewerage and Water Board. Semi-annual report 28th, 1913. *New Orleans, 1913.* Gift of the board.

New York Metropolitan Sewerage Commission. Report, 1914. *New York, 1914.* Gift to the commission.

Oil Fuel for Steam Boilers, R. T. Strohm. *New York, 1914.*

Poor's Manual of Public Utilities, 1914. *New York, 1914.*

Power and Power Transmission, E. W. Kerr. ed. 3. *New York, 1914.*

Practical Pattern Making, F. W. Barrows. ed. 2. *New York, 1914.*

Schubstangen und Kreuzköpfe, H. Frey. *Berlin, 1913.*

Scientific Determination of the Merits of Automobiles, A. Riedler. *London.*

"The Shipbuilder" Annual International Number, 1914. *Newcastle-upon-Tyne, 1914.* Gift of Shipbuilder.

Slide-Rule Notes, H. C. Dunlop and C. S. Jackson. *London, 1913.*

Society for the Promotion of Engineering Education. Proceedings of 21st annual meeting. vol. 21. *Ithaca, 1914.* Gift of Society.

Spinnerei und Weberei, Georg Lindner. *Karlsruhe.*

Strength of Materials, H. E. Murdock. *New York, 1911.*

Technical Thermodynamics, Gustav Zenner, translation by J. F. Klein. vols. 1-2. ed. 2. *New York, 1908.*

TRADE CATALOGUES

Aerothrust Engine Co., *Chicago, Ill.* The Aerothrust for the mechanical propulsion of rowboats, canoes and small sailing craft. The Aerothrust for the mechanical propulsion of bicycles, ice craft, wind wagons, etc.

Bacharach, Herman, *Pittsburgh, Pa.* Catalog B. Hydro volume and pressure recorders.

Consolidated Expanded Metal Co., *Pittsburgh, Pa.* Steelcrete guards, 34 pp. Universal slab computer.

Garrett, Richard, & Sons, *Leiston, England.* The "Garrett" superheated steam semi-stationary engine.

Johns-Manville, H. W., Co., *Cleveland, Ohio.* J-M Roofing salesman, May 1914.

Link Belt Co., *Philadelphia, Pa.* Book no. 190. Wagon and truck loaders, 1914.

North Western Expanded Metal Co., *Chicago, Ill.* Expanded metal construction. June 1914.

Otis Elevator Co., *New York, N. Y.* Escalators, 35 pp.; hand power elevators, 28 pp.; incline railways, 27 pp.; Inclined elevators, 32 pp.; residence elevators; traction elevators, 23 pp.; gravity spiral conveyors. Description of following: Ceiling machine with motor direct connected; double belt ceiling type machine; double screw alternating current machine with full magnet controller; electric sidewalk hoist with hand rope control; hydraulic plunger sidewalk hoist; plunger passenger elevator level control; single screw direct current electric elevator switch control; standard hydraulic elevator vertical cylinder geared type; traction elevator overhead type direct current switch control; duplex geared traction elevator overhead type switch control; single geared traction elevator overhead type switch control.

Pacific Flush-Tank Co., *Chicago, Ill.* Miller appliances, designed for sewage disposal. Catalog no. 15, automatic air-lock apparatus for flushing sewers and handling sewage. Watertight sewer joint compounds.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

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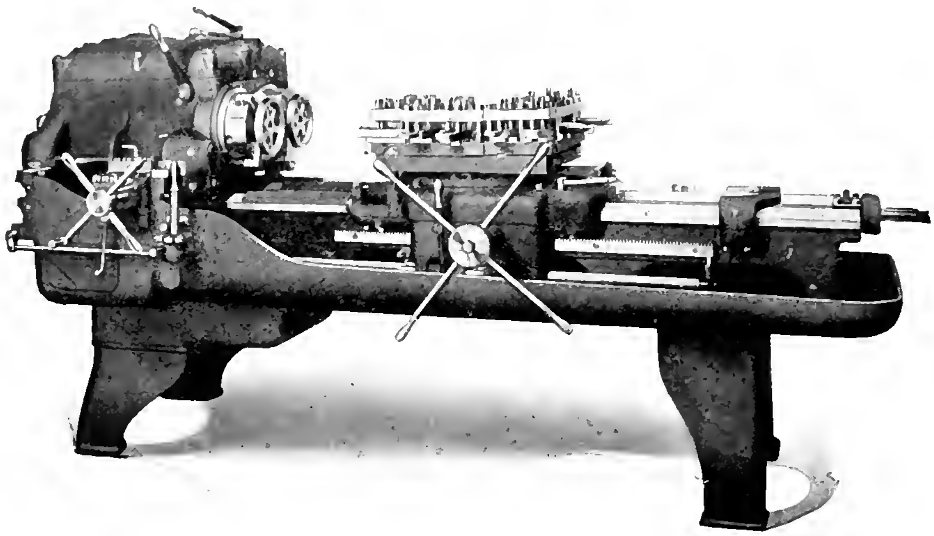
[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1914, and in the January and July 1914 issues of The Journal

Experience—Integrity—Capital



Three very important factors in the manufacture of highly efficient Turret Lathes.

Three items which figure strongly in the manufacture of Jones & Lamson Turret Lathes.

With a record of more than half a century as specialists, designing and building Turret Lathes of the highest type; an enviable reputation for prompt and fair dealing, and sufficient capital to exploit every suggestion in the way of improvement, we have developed the commercially-ideal Turret Lathe.

In the July issue of the *Journal of the American Society of Mechanical Engineers* we explained how nine changes of feed ranging from 20 to 120 per inch could be obtained by a slight shift of a single controlling lever; how the gear feed mechanism, in the hands of others, has stood a test which astonished—*even us*.

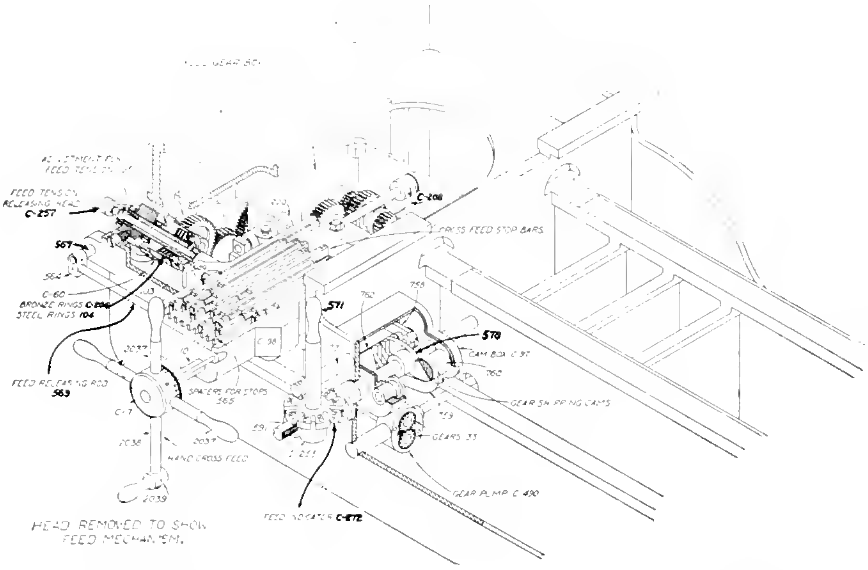
In this grueling test over half a million changes of feed were made without even so much as the removal of a single part for repair; furthermore, the mechanism was apparently in good condition at the end of that period.

Now, allow for rough handling of new and inexperienced operators, neglect of proper lubrication, the continuous grind this mechanism is subject to, and numerous other hardships, then take a pencil and make note of this phenomenal test, and when a new Turret Lathe is under consideration, refer to this matter and purchase on the well known conservative basis—elimination by comparison.

The brief outline and drawing on the next page will explain why this phenomenal test was possible.

Positive Feed and Precision Stops

The section drawing below shows the feed controlling mechanism and the simple but accurate stopping device, found only on Jones & Lamson Machines.



A slight shift of lever No. 571 (see drawing for part numbers) actuates a double wing cam No. 578 which in turn actuates two levers connecting with separate shafts, each carrying an arm C-208 for shifting the gears and obtaining nine feeds ranging from 20 to 120 per inch, shown on the "feed indicator" C-272. The change gears in the "feed gear box" are subject to severe duty, even in the hands of a skilled operator, but this has been provided for by special heat treated gears, specially designed for rapid change work, and partly submerged in oil.

Controlling lever No. 571 has another function, that of the action of rod No. 569 which actuates rod No. 567. On one end of rod No. 567 a small eccentric actuates the adjustable "tension releasing head" C-257 which in turn acts on a series of friction discs C-204 and 104 which have a very important function in effecting a positive and accurate stop for the Cross Sliding Head.

When the Cross Sliding Head has been arrested by striking one of the "cross feed stop bars," instead of the release and rebound action peculiar to other types of feed and stop mechanism, these friction discs perform the important duty of holding the head or carriage firmly against the stop, perfectly rigid, effecting an accurately-finished shoulder on the work.

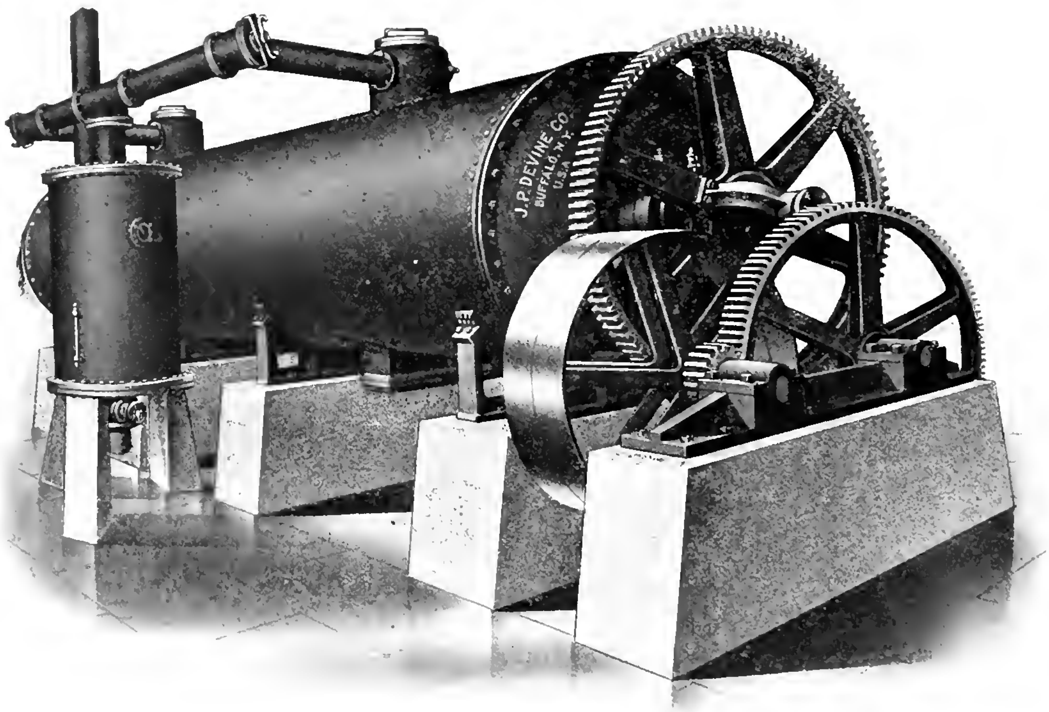
This is the simplest and most efficient feed and stop device for machines of this type, and is but one of the many features which characterize the Jones & Lamson Turret Lathes. Its simplicity of construction makes it indestructible. Its mechanical principle makes it most efficient.

Drying Problems May Confront You

Our

Vacuum Drying Apparatus

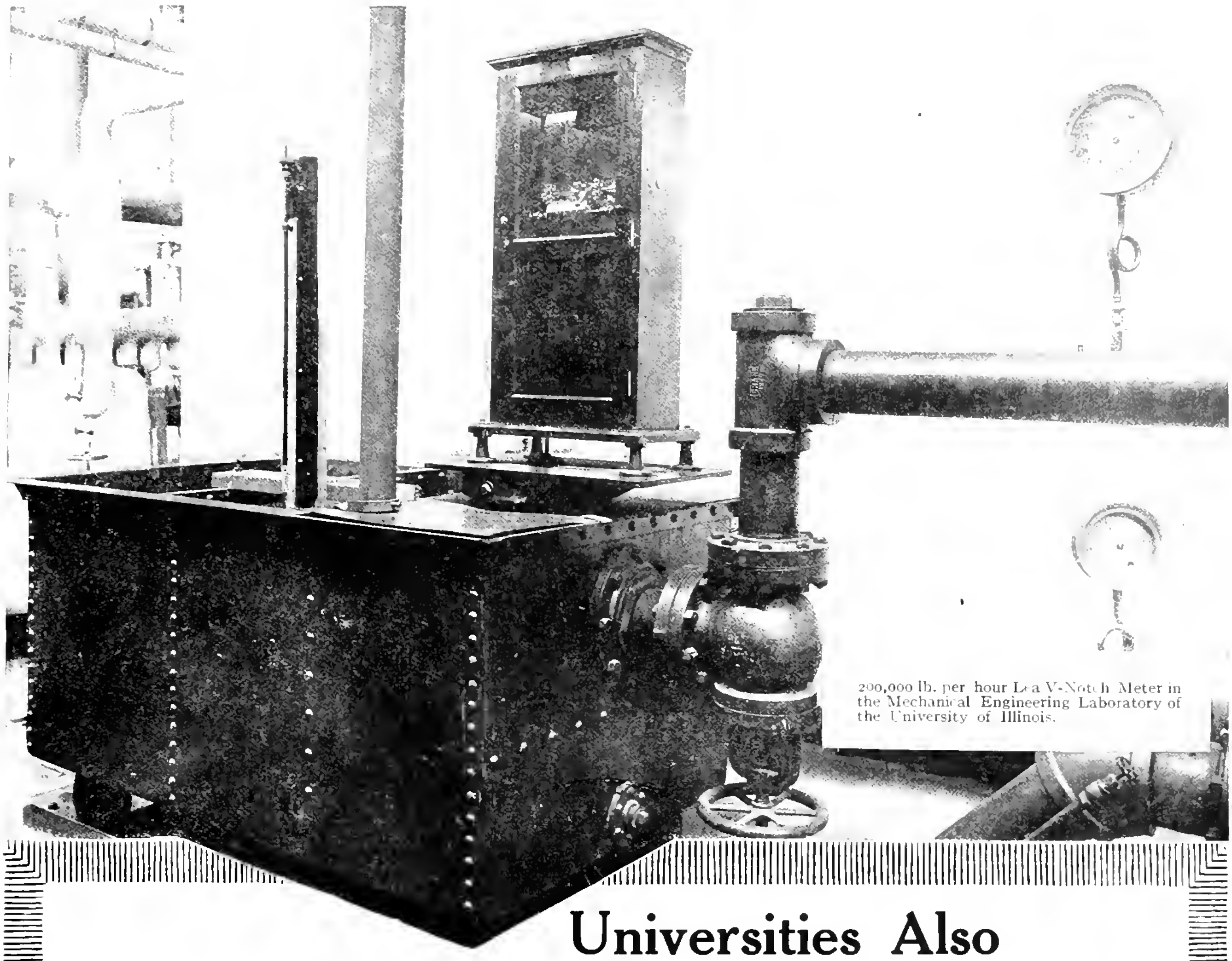
removes moisture, at lowest temperature, rapidly, thoroughly, uniformly, economically. Thirty years of experience in this one field of activity cannot help but be of value to you.



The thousands of installations in daily operation and the many repeat orders are the best evidence of our claims to be of service.

J. P. DEVINE CO.

1372 Clinton Street Buffalo, N. Y.



200,000 lb. per hour Lea V-Notch Meter in the Mechanical Engineering Laboratory of the University of Illinois.

Universities Also Standardize with the "Lea"

In addition to the universal use of the "Lea" V-Notch Recording Meter by big power plants everywhere for the measurement of boiler feed, condenser discharge and other liquid flow, this instrument is also a part of the regular engineering laboratory equipment of a large number of leading colleges and universities both here and abroad. The photograph shows the

"LEA" V-Notch
Recording Liquid Meter

"Log Book of the Power Plant"

in the Mechanical Engineering Laboratory of the University of Illinois.

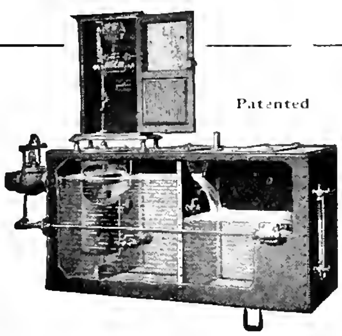
This meter, which is of 200,000 lbs. per hour capacity, has a steel tank and is provided with a multiple V-Notch plate with three V-Notches, 90°, ½ 90°, and ¼ 90°. The ½ and ¼ 90° Notches give a larger float movement and therefore greater accuracy when only small flows are being measured.

The fact that these big universities consider a knowledge of the "Lea" Meter essential to the thorough education of the men entering practical engineering work, is splendid evidence of the necessary part "Lea" Meters will play in the efficient power plant of the future.

The new "Lea" catalog, an 88 page textbook on power plant water measurements, is just coming off press. We must have your name and address in order to send you a copy. **Write for it to-day. No obligation, of course.**

Some of the Universities "Lea" Equipped

Dartmouth College,
Leland Stanford, Jr., University,
University of Michigan,
University of Minnesota,
University of Illinois,
University of Pennsylvania,
University of West Virginia,
George Peabody College,
Dundee Technical School

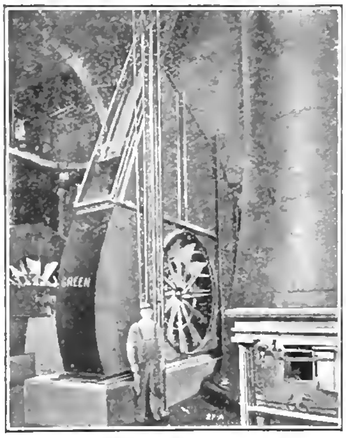


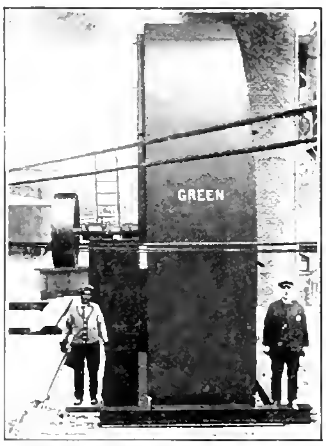
Brief Advantages of the "Lea" Recording Meter

1. Continuous, charted records of flow.
2. Guaranteed accurate within 1½%.
3. Accuracy unaffected by changes in temperature or velocity of flow; by dirt, scale or sediment.
4. Can be checked accurately while running.
5. No moving parts in path of flow.
6. Through educative and moral effect, gives increased efficiency of entire power plant.

Yarnall-Waring Company

Mermaid Ave., Chestnut Hill, Philadelphia

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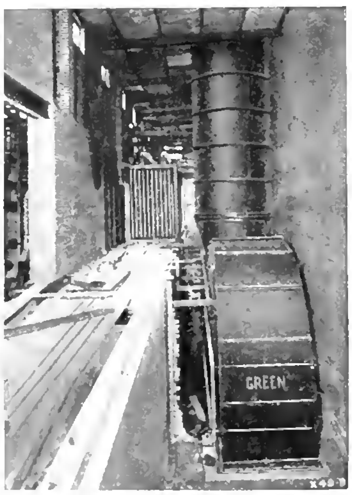
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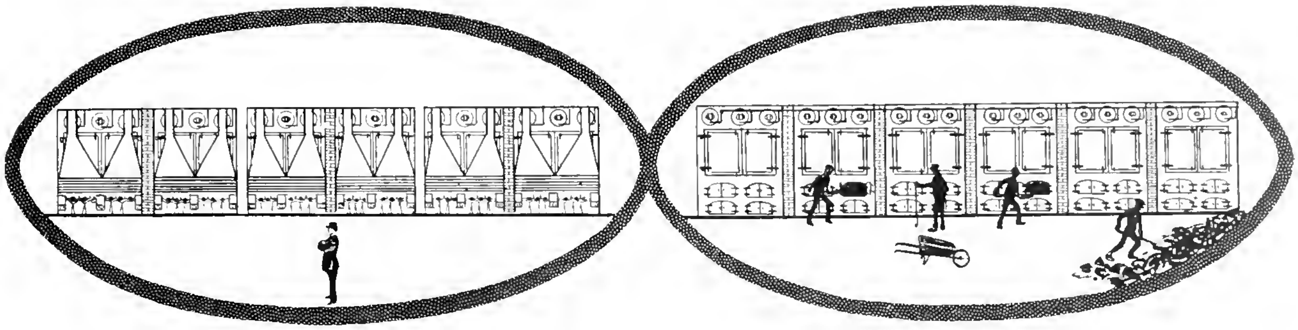


Firing Cost Must Be a Prime Consideration in Power Plant Design

This fact is sometimes overlooked in the effort to construct a plant of minimum first cost and requisite capacity. But boiler room labor cost may mount so enormously with some systems of combustion as to add very seriously to station operating expense.

LABOR ECONOMY is another respect in which

The Taylor Stoker

shows its advantage over other steam making systems.

For instance, 3 batteries of 2-650 h.p. boilers each, TAYLOR STOKERED, may easily be cared for by one man through all variations of load (this is a very conservative estimate), which at a rate of 30c. an hour figures $7.20 as the labor cost for the six boilers. A like number of hand-fired boilers will require 4 men in each of the shifts including the two daily peaks, and at least two men in the slack shift, figuring $24.00 as the day's labor cost.

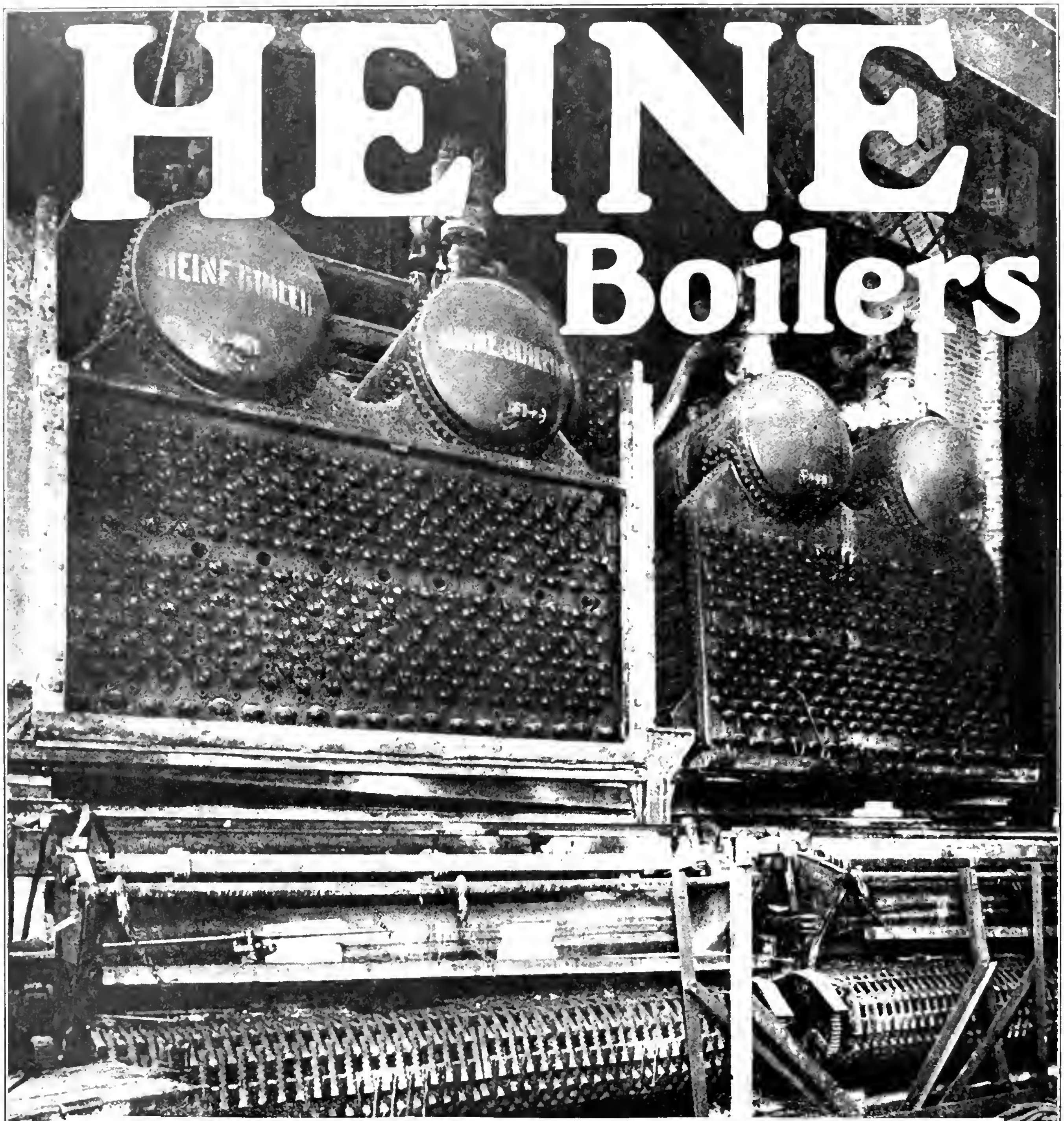
The hand fired boilers can probably not be operated to produce more than 125% rating at peaks, or 4825 h.p., while the TAYLOR STOKERED boilers can easily produce 300% rating, or 11,700 h.p., making the labor cost per produced horse-power with the TAYLOR STOKERS less than one ninth that with the hand fired system, and the ratio for the whole day would probably be as one to five.

Of course this is a hypothetical case, and as an estimate for a whole plant omits the 6 boilers' share of firing supervision, but it shows rather accurately the proportion in labor economy, and explains how a moderate sized plant, like the Hartford Electric Light Company, for instance (5,000 h.p.), has been able to save over $17,000 a year in labor costs alone by a change to TAYLOR STOKERS.

From the above data, figure what the saving would be in a large sized plant, and write our Stoker Department for details.

American Engineering Co.

Philadelphia



3114 Horse Power of Heine Boilers

THE photograph above shows two of six large Heine Boilers with Heine superheaters for 100° superheat in course of erection in a modern central station plant.

The boilers are of the two pass type, giving a long path for the flow of the gases and low flue gas temperatures.

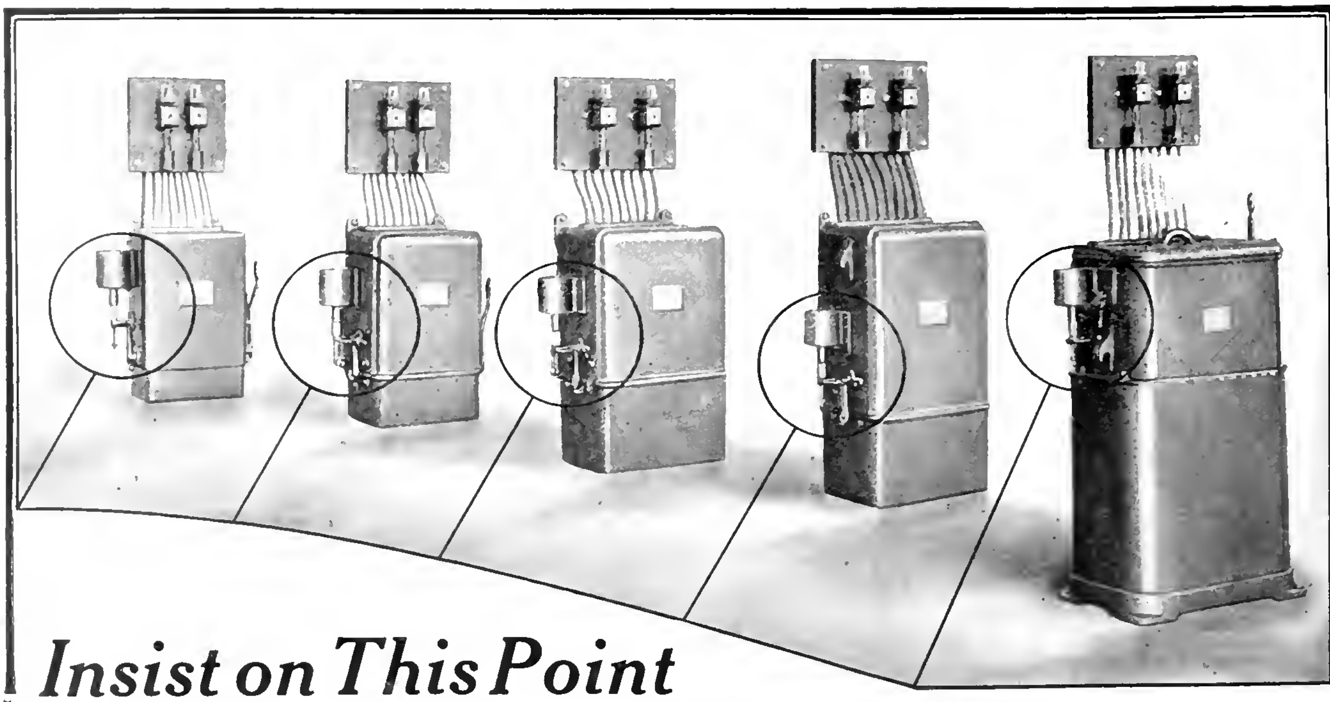
The chain grate stokers are set flush with the boiler front but large furnace capacity and perfect combustion is secured because baffle tiles, on the lower row of tubes, form a roof for a combustion chamber and insure a long length of unchilled flame. **This is the simplest and logical setting for chain grate stokers.**

If the Heine Boiler with horizontal baffling is not used, the stoker must be extended beyond the front of the setting and the boiler set extremely high, with corresponding increase in cost.

For further information on large Heine Boilers, send for our pamphlet, "Large Heine Boilers," also "Boiler Logic" and "Superheating."

HEINE SAFETY BOILER CO.

2465 E. Marcus Ave. St. Louis, Mo.



Insist on This Point

Specify the Low Voltage Release and get the benefits of the most modern method of controlling squirrel cage induction motors.

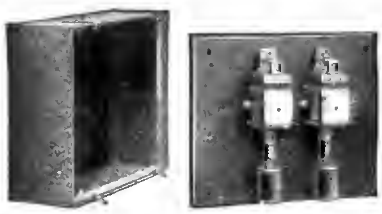
The Low Voltage Release throws the compensator to the off position whenever voltage fails.

Fuses are saved and men as well as the machines are protected because the return of voltage finds every compensator switch in the "off" position —and the motor cannot start until the operator performs the usual starting operations.

Other Advantages of the G-E Compensator

1. The handle of the CR-1034 compensator cannot be left in starting position.
2. The handle cannot be moved to running position without first going to the starting position.
3. Switches are oil immersed, thus eliminating sparking and insuring long life of contacts.
4. Compound treatment of the coils makes them practically water-proof.
5. Overload relays open the circuit in case of overload.
6. The overload relay is supplied with an enclosing cover, making the entire equipment fire-proof.

G-E Industrial Control can be furnished for the practical and economical operation of any motor anywhere.



Overload relay panels are furnished with an enclosing cover

Call, write or telephone our nearest office for further details and special information on our exchange proposition.

General Electric Company

Largest Electrical Manufacturer in the World

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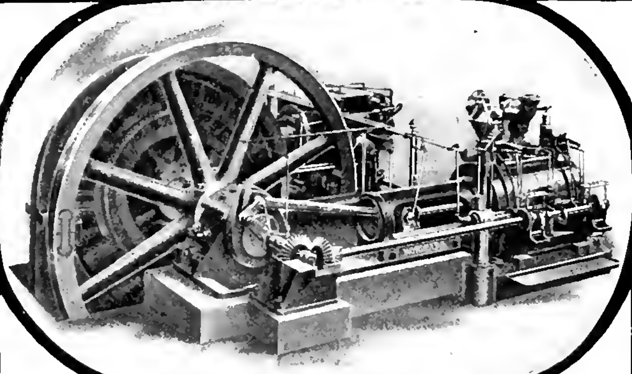
For Texas, Oklahoma and Arizona business refer to Southwest General Electric Company (formerly Hobson Electric Co.), Dallas, El Paso, Houston and Oklahoma City. For Canadian business refer to Canadian General Electric Company, Lt'd, Toronto, Ont.

4450

75% Efficiency with the NORDBERG POPPET VALVE ENGINE



A RECORD performance was made on the acceptance test of the Nordberg Cross-compound Poppet Valve Engine built for the U. S. Metals Refining Co., Grasselli, Ind.

This engine, illustrated above, has Nordberg Poppet Valves on the high-pressure cylinder and Nordberg Corliss Valve with full stroke gear on low-pressure cylinder.

On test with 155 lbs. boiler pressure, 76° superheat and 26″ vacuum, this engine showed an economy of 11.015 lbs. per horse power hour, which corresponds to 75.3% efficiency, as compared to the theoretical or Rankine cycle efficiency.

Nordberg Poppet Valve Engines have been built for over 20 years. Some of the first Poppet Valve Engines are still in operation.

They are built in all sizes, simple or compound, condensing or non-condensing. Compound Engines have Poppet Valve high-pressure cylinders and Corliss Valve low-pressure cylinders.

For further information write for our Bulletin 25

NORDBERG MACHINERY

NORDBERG MFG. CO.

Milwaukee Wisconsin

Manufacturers of High Efficiency Corliss Engines; Uniflow Engines; Poppet Valve Engines; Air Compressors; Blowing Engines; Hoisting Engines; Pumping Engines; and other machinery.

11

Forty Years' Experience in Building Special Machines

for knitting mills, paper making, wood working and nearly every other kind of purpose has fitted us to help you solve your own problems.

Let us build your special machine or contract machine work in our large modern factory. The methods and tools which we employ insure rapid production of accurate work at a reasonable cost.

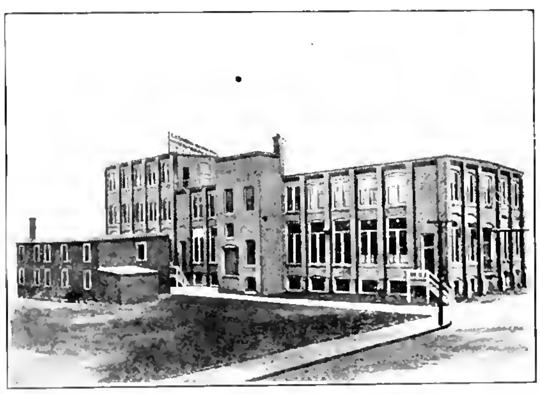
We'll relieve you of every detail of the manufacturing end, leaving you free to devote your time to the sales.

A trial order is solicited
Estimates gladly furnished from blueprints
Write

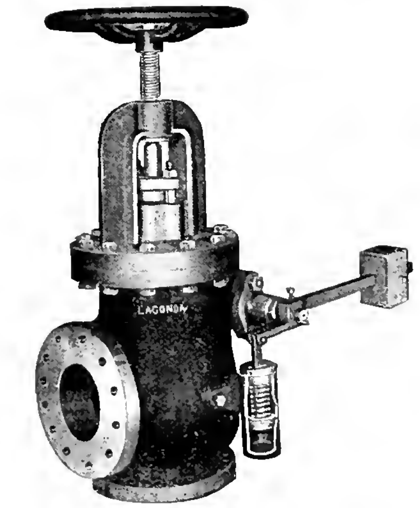
We hold all Plans and Execute all Work in Strict Confidence

C. H. Cowdrey Machine Works

FITCHBURG, MASS.



Contractors, Builders and Designers of Special Machinery



The Lagonda Automatic Cut-Off Valve Is the Circuit Breaker of the Boiler Plant

Just as the circuit breaker protects electrical apparatus, the Lagonda Automatic Cut-off Valve protects your boilers and steam apparatus against accidents and sudden disastrous overload. It isolates trouble and prevents explosions due to improper paralleling of boilers. It is the accurate gauge which tells when boilers are at the proper pressure to be thrown in on the line and it does this automatically.

The bursting or drawing of a boiler tube from the tube sheet will immediately close the valve, removing the injured boiler from the line so that it will not interfere with the operation of the remainder of the plant.

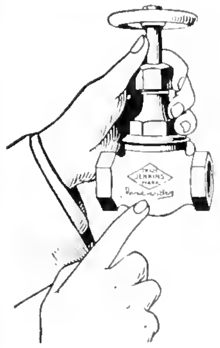
The Boiler Insurance Companies

recommend automatic cut-off valves and the results of U. S. Government tests on Lagonda Cut-off Valves have proved most favorable for their adoption.

Our new Bulletin contains information worth having. Send for copy now.

The Lagonda Mfg. Co.
SPRINGFIELD, OHIO
FUEL SAVING SPECIALISTS
NEW YORK, BOSTON, PHILADELPHIA, ST LOUIS, CHICAGO, DETROIT
DALLAS, SAN FRANCISCO, ST PAUL, MONTREAL, LONDON

Makers of Weinland Boiler Tube Cleaners, Automatic Cut-Off Valves, Reseating Machines, Boiler Tube Cutters and Water Strainers

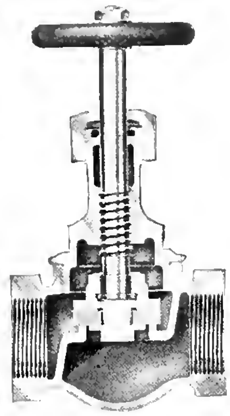


There is only one genuine "Jenkins" Valve. It's the

JENKINS BROS.

and it bears this Trade Mark

Jenkins Bros. Valves are made in all types and for all pressures and purposes.



Jenkins Bros. Standard Pattern Valves, brass and iron body, are the original renewable disc valves. Instead of a solid metal clapper they contain a disc holder made of brass or other suitable material, and a removable disc of a softer material. The Jenkins Disc adopts itself to inequalities in the seat, thus insuring perfect tightness. If the disc is injured, or becomes worn out in service, it may be easily replaced, thus making valve as good as new at very little expense. The complete valves seldom wear out in service. There are numerous places where Jenkins Bros. Valves installed 25 to 40 years ago are still in service. Engineers have often testified that Jenkins Bros. Valves outlast all others with which they have had experience.

Let us send you catalog illustrating the complete line

The Diamond Trade Mark Is Your Protection

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Jenkins Bros.

Jenkins Bros.

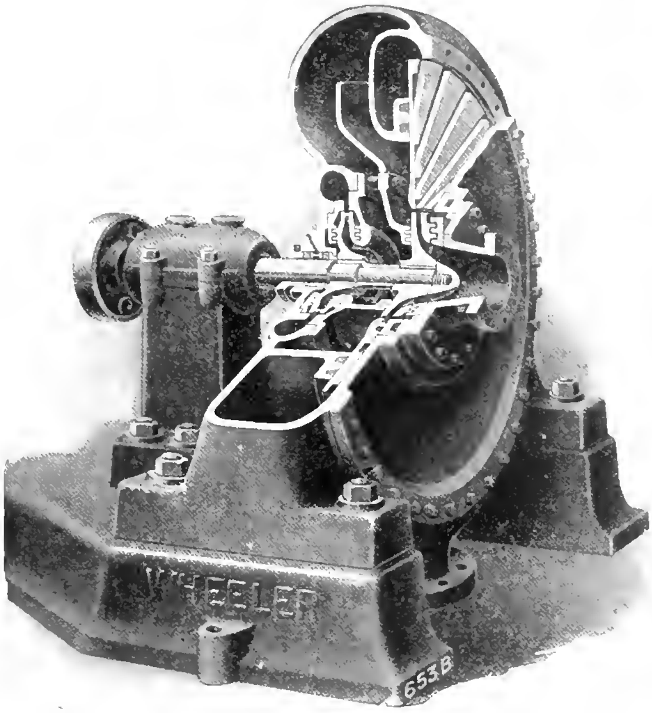
New York, Boston, Philadelphia, Chicago

Jenkins Bros., Limited, Montreal, P. Q., London, E. C.

THE

AIR PUMP

For Large Turbine Units



THE Wheeler Turbo Air Pump is particularly suited for condensers of 10,000 kw. and up, because the hurling water is discharged around the entire periphery of the impeller, in small radial jets, and large air entraining capacity is obtained. The air is positively entrapped between small layers of water, the compressed mixture being finally discharged into a casing surrounding the diffuser.

Under ordinary air-tight working conditions, when the condenser air in leakage is small, the

WHEELER
Turbo Air Pump

will maintain a vacuum of 99% of the theoretical.

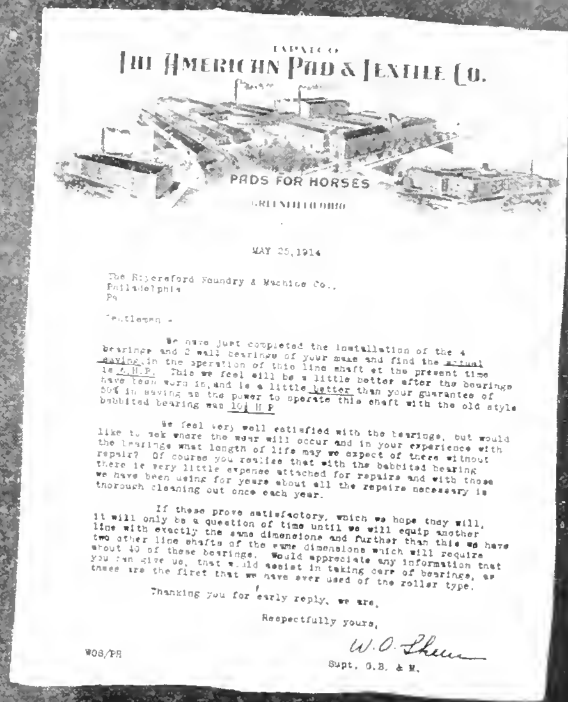
For surface condensers a combined air and condensate pump is preferred by some engineers, and this arrangement is shown in the illustration. Air and condensate enter the pump by a common suction nozzle, and are separated within the pump, the air flowing over the division wall to the periphery of the hurling water impeller and the condensate flowing by gravity to the eye of the condensate impeller.

This pump saves floor space piping, attendance and power

For further information on Wheeler Turbo Air Pumps, send for our new Bulletin 111

WHEELER
Condenser and Engineering Co.
CARTERET NEW JERSEY

Do "Sells" Bearings Save Power?


THE AMERICAN PAD & TEXTILE CO.

PADS FOR HORSES

MAY 25,1914

The Royersford Foundry & Machine Co.,
Philadelphia
Pa

Gentlemen -

We have just completed the installation of the 4 bearings and 2 wall bearings of your make and find the actual saving in the operation of this line shaft at the present time is 6 H.P. This we feel will be a little better after the bearings have been worn in, and is a little better than your guarantee of 50% in saving as the power to operate this shaft with the old style babbited bearing was 10½ H P

We feel very well satisfied with the bearings, but would like to ask where the wear will occur and in your experience with the bearings what length of life may we expect of these without repair? Of course you realize that with the babbited bearing there is very little expense attached for repairs and with those we have been using for years about all the repairs necessary is thorough cleaning out once each year.

If these prove satisfactory, which we hope they will, it will only be a question of time until we will equip another line with exactly the same dimensions and further than this we have two other line shafts of the same dimensions which will require about 40 of these bearings. Would appreciate any information that you can give us, that would assist in taking care of bearings, as these are the first that we have ever used of the roller type.

Thanking you for early reply, we are,

Respectfully yours,

W. O. Sheer

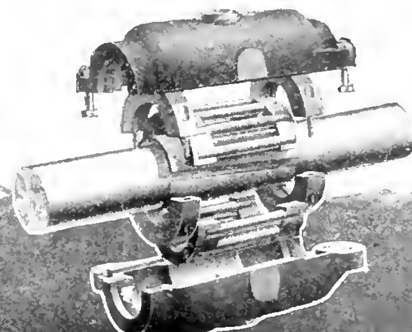
WOS/PR

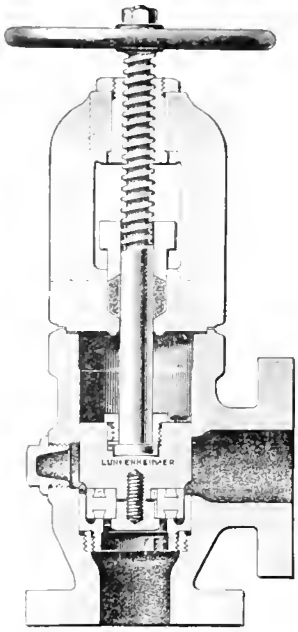
Supt. G.B. & M.

A Drop from $10\frac{1}{2}$ to $4\frac{1}{2}$ Horsepower

FIFTY-seven-and-one-eighth per cent. less power needed to do the work a week after "Sells" Roller Bearings were applied! This—the experience of the American Pad & Textile Company—is only one of the hundreds of instances where "Sells" Bearings are cutting the cost of manufacture. And, as we will show in another letter, this saving improves from year to year *without a single cent of repair cost.* Let us analyze your proposition now—no obligation, and an opportunity for big savings. Don't fail to write for the facts.

Royersford Foundry & Machine Co.
60 N. 5th St , - - Philadelphia, Pa.





LUNKENHEIMER BLOW-OFF VALVES

Made in Bronze and Iron Body Bronze Mounted. Either Straightway or Angle Pattern can be furnished. All patterns equipped with self-cleansing seat feature, insuring the greatest durability.

Besides the above, the large and complete line of Lunkenheimer high grade engineering specialties includes Bronze and Iron Body Bronze Mounted Globe, Angle, Cross, Check, Throttle, Gate, Non-return Boiler Stop, Lever, Pop Safety, Relief, Screw Down Check Valves, etc.; "Puddled" Semi-steel and Cast Steel Valves of all types; Water Columns, Gauges and other Boiler Mountings; Whistles and Ground Key Work of all descriptions; Injectors and Ejectors; Lubricators and Lubricating Devices; Oil Pumps, Oil and Grease Cups; Gasoline Engine Appliances, etc.

Your local dealer can furnish them; if not, write us.

A complete description of the entire line is given in Lunkenheimer Catalogue No. 50. If you haven't a copy, write for one.

THE LUNKENHEIMER CO.

"QUALITY" 16-4b

Largest Manufacturers of High Grade Engineering Specialties in the World

CINCINNATI, OHIO

New York - - Chicago - - Boston - - London

FLEXIBILITY

From a salesman's report, dated Dec. 8, 1913:

Mr. [redacted], superintendent of the [redacted] plant, advised that the Goodrich Conveyor Belt recently furnished them is one of the most satisfactory belts he has ever handled; it runs so absolutely true that he has removed every guide idler from the installation.

(*We will furnish name of this plant upon request*)

Goodrich

LONGLIFE and MAXECON CONVEYOR BELTS

reduce tonnage costs

Makers of Goodrich Tires and Everything that's Best in Rubber

There is nothing in Goodrich Advertising that isn't in Goodrich Goods

Factories: Akron, Ohio

The B. F. Goodrich Company

Branches in All Principal Cities

C. H. Wheeler Condensers

We guarantee our apparatus to maintain a vacuum as close to absolute as is commercially possible, and with the lowest operating and maintenance cost.

The C. H. WHEELER "High Efficiency" System of Steam Auxiliaries includes:

- **C. H. WHEELER** High Transmission Surface Condensers.
- **C. H. WHEELER** Counter Current Central Barometric; and High Vacuum Low Level Jet Condensers.
- **C. H. WHEELER-PRATT** "ROTREX" Patent Vacuum Pumps.
- **C. H. WHEELER-MULLAN** Patent Vacuum Pumps.
- **C. H. WHEELER-THYSSEN** Hydraulic Entrainment Type High-Speed Vacuum Pumps.
- **C. H. WHEELER** IMPROVED Rotative Dry Vacuum Pumps.
- **C. H. WHEELER** Centrifugal Pumping Machinery, all capacities, Belt, Engine, Turbine or Motor driven.
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Multiflex Automatic Relief Valves.
Expansion Joints.

"Everything but the Turbine"

C. H. WHEELER MANUFACTURING CO.

PHILADELPHIA, PENNA.

BRANCHES

New York	Pittsburgh	Chicago	San Francisco	New Orleans
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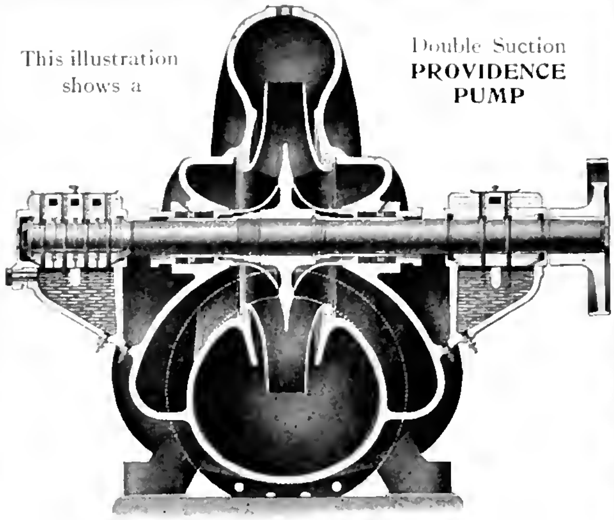
This illustration shows a

Double Suction **PROVIDENCE PUMP**



PROVIDENCE PUMPS

are built for all purposes in capacities of 100 to 100,000 gallons per minute.

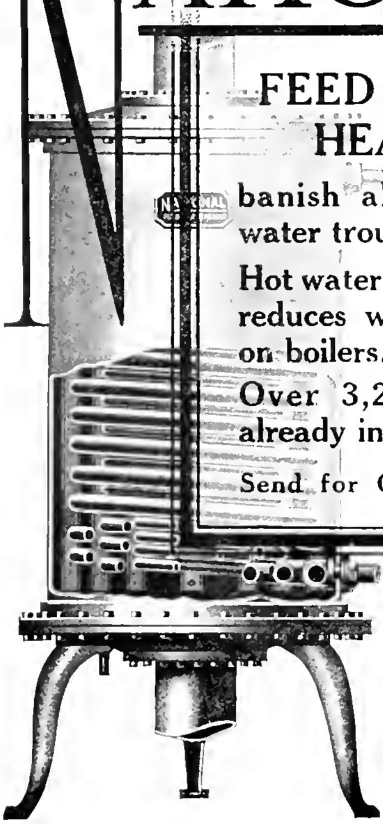
Double Suction Pumps for moderate heads.
Stage Pumps for greater heads or pressures.

Send for Bulletin

PROVIDENCE ENGINEERING WORKS
Providence, Rhode Island

NATIONAL

FEED WATER HEATERS



banish all your feed water troubles.

Hot water saves fuel and reduces wear and tear on boilers.

Over 3,250,000 h.p. already installed.

Send for Catalog No. 51

The National Pipe Bending Co., New Haven, Conn.

46-73

TEXACO

TEXACO LUBRICANTS

Whether you use, make, or sell power, you must employ lubricants.

The care with which you select them influences the efficiency of your plant.

The care with which we have selected the Texaco Lubricant most suited to each purpose insures the utmost in lubricating efficiency to the consumer.

We have customers operating plants of all sizes and every description, who are daily attesting to the advisability of buying oils under the Texaco Red Star Green "T" trademark.

Investigate. It will benefit us both.

The Texas Company

Houston **New York**

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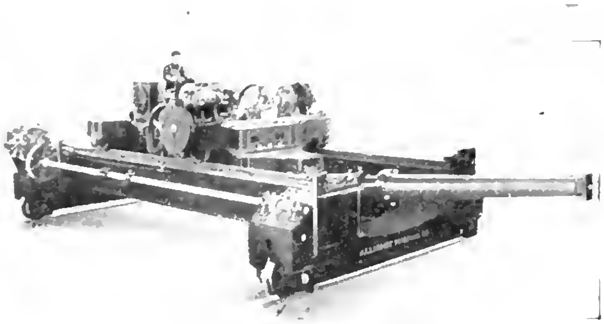

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FLOOR TYPE

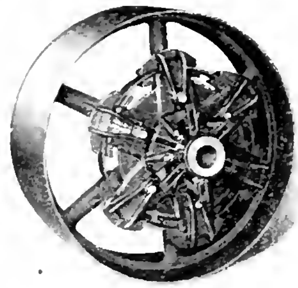
Open-Hearth Charging Machine

Massive—Compact
Very Accessible

An all-steel construction floor type open-hearth charging machine designed to meet the hard service incident to apparatus of this character. Massive and compact, but at the same time very accessible.

PITTSBURG *The Largest Manufacturers of the World's Largest Cranes* NEW YORK

THE ALLIANCE MACHINE CO.
ALLIANCE, OHIO.
BIRMINGHAM **ENGINEERS AND BUILDERS** CHICAGO



6-Arm Friction Clutch Pulley

Power Transmission Appliances

FOR

BELT AND ROPE DISTRIBUTION

Mechanical, Economical, Efficient

Friction Clutch Pulleys	Hangers and Pillow Blocks
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Friction Clutch Operators	Shaft Couplings
Head Shaft Hangers	Floor Stands
Sheaves	Tension Carriages

Forged and Turned Shafts, etc., etc.

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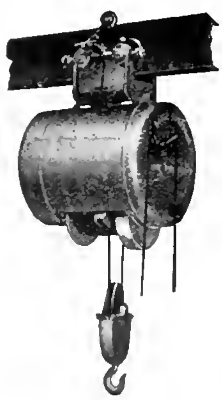
HOISTS

Capacities from 1-2 to 6 Tons
Direct and Alternating Current



SIMPLE—RELIABLE EFFICIENT

Sprague Hoists are cutting the cost of production in many industries.

Write for Pamphlet No. 90560

Illustrating applications in many industries.

Complete information upon request

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OF GENERAL ELECTRIC COMPANY

Main Offices: 527-531 West 34th Street

NEW YORK, N. Y.

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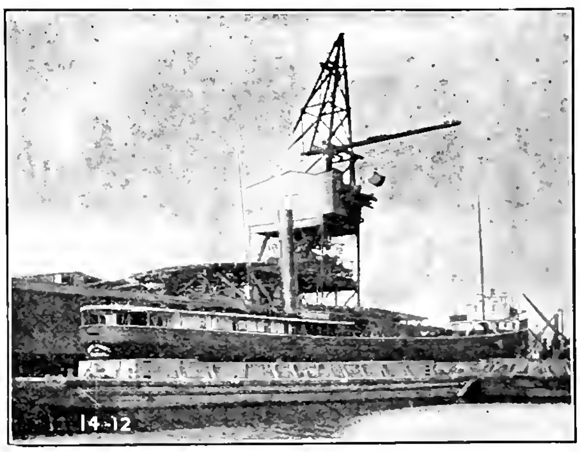


HUNT STEAM OPERATED ONE MAN CONTROL STEEPLE TOWER

WILSON & PATTERSON, Montreal, Quebec

The Hunt Tower illustrated above, in combination with Hunt Automatic Railway, unloads coal and places it in storage at the rate of 200 tons per hour.

A VERY EFFICIENT OUTFIT

We are Specialists in machinery for the economical handling of bulk material, and solicit inquiries for equipment of this kind.

Pamphlet S-102 on request.

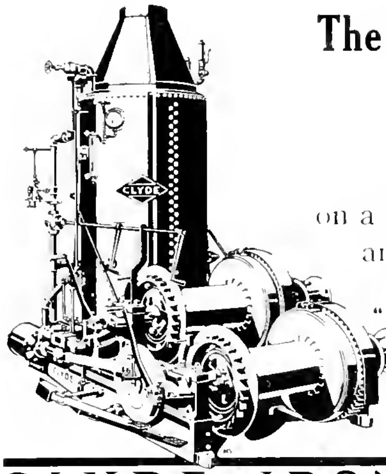
C. W. HUNT CO., Inc.

West New Brighton, N. Y., U. S. A.

45 Broadway, N. Y. City — Fisher Bldg., Chicago
Evans Building, Washington

Fifty Cents a Day

added to your operating costs will soon make up the difference between the cost of a CLYDE and that of a cheaper hoist. Now the Clyde Hoist is made with the one idea of doing the work more economically: — you can count on the saving, which will go on long after the difference in cost is wiped out.



The Clyde Diamond

CLYDE

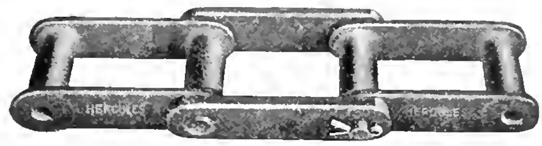
on a hoist means a guarantee of satisfaction.

"You'll find a Repeat-Order built into every Hoist of Clyde-Grade"

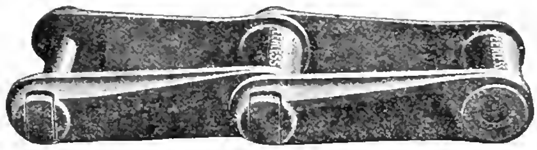
CLYDE IRON WORKS
MANUFACTURERS of CLYDE-GRADE HOISTING MACHINERY
Duluth, Minnesota U.S.A.

Jeffrey Long Service Chains

Specially designed for Extra Heavy Work and for the handling of Gritty or Abrasive Materials.



"Hercules" Combination Malleable Link and Steel Side Bar Chain, with Steel Pins.



"Peerless" Malleable Link Chain with Steel Pin; Renewable Bushings.

Jeffrey *CHILLED RIM* Sprocket Wheels
Hardened by the **J-Co. Process,** when used in connection with these chains, make a combination that is unsurpassed for Durability and Economy.

WRITE FOR BULLETIN

JEFFREY MFG. CO., Columbus, O.

O. S. LOCOMOTIVE CRANES

and PATENT CLAM SHELL BUCKETS

Standard and Broad Gauge with Block, Bucket or Magnet

are part of our complete line of Material Handling Machinery, including Gantry and Cantilever Cranes, Drag Line Excavators, Coal Crushers, Electric and Steam Hoists, Bridge and Pillar Cranes, Elevating and Conveying Machinery.

Bulletin No. 9 describes and illustrates many types and is sure to interest you

ORTON & STEINBRENNER CO.
Main Office: CHICAGO, ILL. **Works: HUNTINGDON, IND.**

Veeder Set Back and Locked Wheel COUNTERS

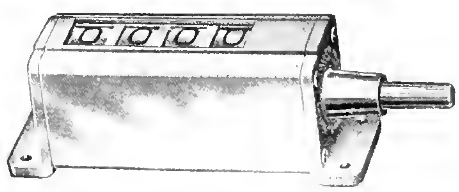
are absolutely reliable instruments for the recording of output from machines.

In their design special attention has been given to making an instrument which will operate with the greatest ease. They are furnished with the following forms of driving mechanism: Revolution, Direct Drive and Rotary Ratchet.

Complete catalogues showing over 25 different styles of counters mailed free upon request

THE VEEDER MFG. CO., Hartford, Conn.
16 Sargeant St.

Makers of Cyclometers, Odometers, Tachometers, Tachodometers, Counters and Small Die Castings



Cut Half Size

The "Locked Wheel" Counter, illustrated above, is similar to the Setback Counter except the number wheels are locked in all positions.

Especially useful where the work is paid for by the piece, as it may be connected up so the figures cannot be moved except by running the machine.

STEAM ENGINES, TURBINES AND BOILERS

THE SMITH GAS POWER CO.

LEXINGTON, OHIO

Builders of Smith Automatic Gas Producers, both suction and pressure types. Mechanically Operated Gas Producers in large units for power and heating plants. Tar Extractors and Gas Cleaning Plants.

See page 22 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Gas Producers

POWER PLANT AUXILIARIES AND SPECIALTIES

AMERICAN BALANCE VALVE CO.

JERSEY SHORE, PENNA

We make Balanced Slide and Piston Valves for Manufacturers of Steam Engines, also for Old Power Equipment, from Steam Pumps to Battleships. Write us.

See page 130 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Valves

Slide and Piston Distribution

AMERICAN ENGINEERING CO.

PHILADELPHIA

Machinists and Founders. Builders of the Taylor Stoker.

Stokers

AMERICAN STEAM GAUGE AND VALVE MFG. CO.

BOSTON, MASS.
ESTABLISHED 1851

Pressure and Recording Gauges, Engine Room Clocks and Counters for all purposes. Iron and Brass Pop Safety and Relief Valves for stationary, marine and locomotive use. The American Thompson Improved Indicator with new improved detent motion. The American Ideal Steam Trap.

See pages 110, 111 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Valves

Gauges

Indicators

THE ASHTON VALVE CO.

BOSTON NEW YORK CHICAGO

Makers of the Ashton Pop Safety Valves, Water Relief Valves, Blow Off Valves, Pressure and Vacuum Gages. All of a superior quality and guaranteed to give greatest efficiency, durability and perfect satisfaction.

Valves

Gages

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Apparatus for and technical information relative to all forms of liquid fuel equipment.

Oil and Tar Burners

Furnaces

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Bristol's Recording Pressure and Vacuum Gauges. Bristol's Recording Thermometers. The Wm. H. Bristol Electric Pyrometers. Bristol's Recording Voltmeters, Ammeters and Wattmeters. Bristol's Recording Water Level Gauges. Bristol's Time Recorders and Bristol's Patent Steel Belt Lacing.

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No. 381. Standard Method of Conducting Duty Trials of Pumping Engines: Committee Report, price $0.30; No. 1144. Balancing of Pumping Engines: A. S. Nagle, price $0.10; No. 1110. Development of Water-wheel Governor: M. A. Replogle, price $0.20; No. 1113. Turbine Design as Modified for Close Regulation: G. A. Bovinger, price $0.10.

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THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

29 West 39th Street, New York

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

INCLUDING THE TRANSACTIONS OF THE SOCIETY

SEPTEMBER · 1914

APPLICATIONS MUST BE FILED BY SEPTEMBER 23

THE SOCIETY is about to enter upon the season of its greatest activity and a program which should prove of unusual interest and value has been planned for the year 1914-1915.

Applications should be filed not later than September 23 by those who are desirous of participating in the privileges which the Society offers, for the following reasons:

To participate in the proceedings of the Annual Meeting which will be held December 1-4.

To be included in the List of Members appearing in the 1915 Year Book.

To secure the published proceedings and Transactions of the meetings held during 1914-1915.

To participate in the frequent meetings held in fifteen cities, thereby enlarging one's professional knowledge, acquaintanceship with the leading members of the profession, etc., etc.

Application forms and information regarding membership may be obtained from the Secretary or from any of the undersigned.

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Total Membership of the Society, August 20, 1914 5891
New Members since January 1, 1914 603

THE JOURNAL OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

Volume 36 SEPTEMBER 1914 Number 9

CONTENTS

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COMING MEETINGS OF THE SOCIETY

September 8, San Francisco, Cal. Subject: Hydroelectric Power Development in Conjunction with that of Domestic Water Supply.

September, St. Paul, Minn. Subject: Power Development on Mississippi River between St. Paul and Minneapolis. (Date of meeting will be furnished upon application to Secy. E. J. Heinen, 708 Commerce Bldg., St. Paul).

October 8, Philadelphia Pa. Joint meeting with the Franklin Institute. Paper on Cast Iron, by J. F. Johnson.

October 22, Buffalo, N. Y. Address by Charles Whiting Baker on a question of Public Service.

November 18, New Haven, Conn. Fall meeting with afternoon and evening sessions, Mason Laboratory of Mechanical Engineering, Sheffield Scientific School, Yale University. Subject: The Generation and Application of Electricity in Manufacturing.

Annual Meeting, December 1–4, New York City. There will be a session on Engineering Metals, particularly Steels of Construction and for Tools; Cast Irons; and Alloys of Copper, Tin and Aluminum, etc.; and the entire day on Thursday, December 3, will be devoted to the general subject of the Engineering in connection with the Administration of a City; the session will be opened by the Mayor of the City of New York. The sub-committees on Railroads, Machine Shop Practice, and Textiles are arranging for sessions, and there will undoubtedly be groups of papers given under the direction of other committees, besides one session at which several important miscellaneous papers will be read.

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

Volume 36 September 1914 Number 9

THE ANNUAL MEETING

DECEMBER 1-4, 1914

Because of the many new developments in the field of Engineering Metals and their application to methods of manufacture, it has been decided to devote a session of the Annual Meeting of the Society, to be held in New York, December 1-4, to this important subject. Steels of construction and for tools, cast irons, and alloys of copper, tin and aluminum, etc., will be among the phases to be touched upon. The intention of the Committee in planning this session is to bring out and to make a matter of common knowledge the advances in this field up to the present time. The Sub-Committee on Iron and Steel will have charge of the session and it is the expectation that four papers will be presented.

In line with the widespread movement among engineers the world over to devote their knowledge to the solution of public problems, the Committee on Public Relations, having charge of the Society's activities in this direction, will provide an all-day meeting on Thursday, December 3, on the subject of Public Service. Papers on municipal engineering and related matters will be presented. The session will be opened by John Purroy Mitchel, Mayor of the City of New York, and the following papers will be given during the day:

Snow Removal, a Report of the Committee on Resolutions of the Snow Removal Conference held in Philadelphia, April 16-17, 1914.

Utilization of Municipal Wastes, by Irwin S. Osborne, designer and operator of the Columbus, O., Garbage Disposal Plant, and consulting engineer of the cities of Philadelphia, New York, Washington, D. C., and Toronto, Canada.

The Training of Municipal Employees, by H. M. Waite, City Manager, Dayton, O.

The Cleaning of Public Buildings, by Wm. H. Ball, Chief, Bureau of City Property, Philadelphia.

The Future of the Police Arm, by Henry Bruére, City Chamberlain, New York City, and Director of the National Bureau of Municipal Research.

Controlling Factors in Municipal Engineering, by Morris L. Cooke, Director, Dept. of Public Works, Philadelphia.

A Study of Cleaning Filter Sands, by Sanford E. Thompson, Consulting Engineer, Newton Highlands, Mass.

Municipal Colleges in Germany, by Clyde L. King, Instructor in Political Science, University of Pennsylvania, Philadelphia.

The Design and Operation of the Cleveland Municipal Electric Light Plant, Frederick W. Ballard, Commissioner of Lighting, Dept. of Public Utilities, Cleveland, Ohio.

In addition, the Committee will be glad to receive short memoranda, covering not more than two pages, outlining any recent changes in the conduct of different kinds of municipal work which tend to put it upon an engineering basis, and which may have come under the observation of our members.

The sub-committees of the Committee on Meetings will again contribute sessions on their special subjects to the meeting. Three papers will probably be presented at a session on Machine Shop Practice, a report on The Steam Locomotive of Today is to be given by the sub-committee on Railroads, and there will be a Textile Session, with two or three papers. Besides these and others yet to be arranged for, there will be one or two miscellaneous sessions, depending upon the amount of time available. Among the papers already selected is one upon the Operation of Grinding Wheels in Machine Grinding, by George I. Alden, and another on a Rate Flow Meter, by Prof. H. C. Hayes.

Plans are already under way, in charge of the New York Local Committee, for the social features of the meeting, which always constitute so important a part of the conventions of the Society.

THE PUBLIC HEARING OF THE BOILER SPECIFICATIONS COMMITTEE

September 15, 1914, in the Rooms of the Society

The work of the Boiler Specifications Committee marks one of the most important undertakings of The American Society of Mechanical Engineers.

During the past few years the introduction of boiler inspection laws in various states and cities has aroused the necessity for the establishment of uniform requirements and the efforts of the Committee in this direction have been generally favored and supported. It has been found that the most important interests are in favor of the best material and construction known, and the letters that have been received particularly from those abroad quite generally indorse the position that has been taken by the Committee.

The basic idea of the Committee's work is the formulation of a standard of the highest requirements, thereby reducing the great loss of life and property in the United States from boiler explosions and derangements, which are for the most part preventable. It is the intention also to create a standard which, it is hoped, will ultimately be adopted by the Federal Government and state governments not now having boiler regulations, and, through uniform legislation, to produce such a condition of affairs that a boiler built for any one state will be acceptable in any other.

Where state legislation has been enacted, it is hoped that it will be modified to conform to the Society's model.

As announced in the August number of The Journal, the preliminary work of the Committee to Formulate Standard Specifications for the Construction of Steam Boilers and Other Pressure Vessels and for the Care of Same in Service, which was completed last February and placed in the form of a tentative report of limited edition for critical study and improvement, is now to be submitted to public hearing for further suggestions and improvement. The tentative draft was issued in an edition of 1500 for a preliminary study and was submitted to recognized authorities throughout the civilized world, including non-members of the Society as well as members; it was sent to boiler manufacturers, prominent steel manufacturers, insurance companies, boiler users, consulting engineers, operating engineers, and all who are known to have special knowledge of the boiler business. With each copy was sent a request that the recipient should take out whatever was considered inadvisable and add whatever would further safeguard human life and property.

At the St. Paul-Minneapolis meeting much interest was shown in the work of the Committee. This was not considered as a report, but a topical discussion of some of the more important phases of steam boiler legislation was held and many of the points in boiler practice on which there was a difference of opinion were considered. There had been a conference at Chicago on Monday, June 15, among representatives of the Committee, the Association of Steel Manufacturers, and the National Tubular Boiler Manufacturers Association, at which the discussion was devoted largely to the steel specifications desired. This discussion was continued at the opening session of the Spring Meeting on Wednesday morning, June 17, and was transferred later to a separate meeting room where it was continued the greater part of the day. The Committee has sought in every way to secure the fullest expression of opinion. The necessity for a careful study of the more important factors involved was emphasized by the Committee, and the result of the discussion was a resolution calling for a public hearing in New York in September, as follows:

Resolved, that on September 15, 1914, the Committee hold in the rooms of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y., a hearing of all interests concerned on the preliminary report of the Committee appointed to Formulate Standard Specifications for the Construction of Steam Boilers and Other Pressure Vessels and for the Care of Same in Service, and that those desiring to participate in the discussion present their criticisms and suggestions in writing prior to August 15th.

Resolved, that in addition to invitations, notification by publication in the technical press be given to the hearing.

Carrying out the policy of the Committee and the Society in all of its determinations, invitations have been sent out to the following associations and engineering organizations known to be interested in the matter of standard boiler specifications:

American Boiler Manufacturers Association
American Institute of Steam Boiler Inspectors
American Railway Master Mechanics Association
American Society of Heating and Ventilating Engineers
American Society of Testing Materials
Association of American Steel Manufacturers
City of Chicago, Department of Boiler Inspection
City of Detroit, Office of Chief Boiler Inspector
City of New York, Department of Boiler Inspection
City of Philadelphia, Department of Boiler Inspection
Committee on Relation of Railway Operation to Legislation
Indiana State Bureau of Boiler Inspection
Industrial Commission of Wisconsin
Interstate Commerce Commission
Marine Engineers Beneficial Association
Massachusetts Board of Boiler Rules
Massachusetts Public Service Commission
Montana State Board of Boiler Inspection
National Association of Boiler Manufacturers
National Association of Cotton Manufacturers
National Association of Stationary Engineers
National Association of Thresher Manufacturers
National Bureau of Standards
National Council for Industrial Safety
National Tubular Boilermakers Association
New York State Commission on Uniform State Laws
Ohio State Board of Boiler Rules
Public Service Commission, 2d District, New York State
State of Illinois
State of Maryland
State of New York
State of North Carolina
State of Pennsylvania, Department of Labor and Industry
State of Virginia

U. S. Board of Supervising Inspectors of Steam Vessels
U. S. Bureau of Steam Engineering
U. S. Department of Commerce

Any one reading this notice and observing any omissions will confer a favor both by notifying the organization of the hearing and the Society, so that an official invitation may be sent. Most of the organizations named have accepted the invitation.

These organizations were invited to be present or to have representation at the hearing which will be held in the rooms of the Society in New York, at 10 a.m., Tuesday, September 15; and all who had not already done so were asked wherever possible to prepare and send a statement in writing previous to the hearing, to assist in the deliberations. A limited number of copies of the draft report are still available and may be secured on application.

The foundation of these rules is the Boiler Law of Massachusetts, which has been enforced for some time and which has recently been adopted by the State of Ohio, the City of Detroit, and the City of Manila in the Philippine Islands. Several of the other states are now considering the adoption of standard rules regulating boilers and other pressure vessels. In the six years that the Massachusetts Rules have been in force, over 8300 boilers have been constructed to that standard and boiler explosions and derangements have been reduced to a minimum.

Much credit is due to the Committee for its tireless efforts in preparing the tentative report and in collating the enormous amount of data embodied in the voluminous recommendations on which the tentative draft was based. The work has involved much self-sacrifice on the part of the members, particularly Mr. John A. Stevens, Chairman, whose extensive experience as a member of the Board of Boiler Rules of the State of Massachusetts, in developing and inaugurating the Massachusetts Standard, has been turned to advantage in the work here undertaken. The other members of the Committee to whom much credit is also given are W. H. Boehm, R. C. Carpenter, Richard Hammond, C. L. Huston, E. D. Meier and E. F. Miller. This work, which is borne exclusively by the Committee members and by The American Society of Mechanical Engineers is for the benefit of the people through the protection of life and property and of the boiler industry at large. It is national in character and its effect will be felt not only by the manufacturing interests in easier conditions for selling, but also will be of similar benefit to the users as it will enable them to secure boilers more promptly and at less cost for a safe boiler.

The Society is rendering a peculiar service in its several activities and is endeavoring to reach the needs of its members both collectively and individually, and the work of such a committee as the Boiler Specifications Committee should have the coöperation and interest of the profession at large.

MEETINGS IN BUFFALO

Among the most successful of the recent organizations of engineers in local centers has been that in Buffalo, and from plans already made for the coming season there is every promise of a decidedly interesting series of meetings in store for the members.

As now planned, there are to be fourteen meetings, commencing October 22 and ending May 6. The program is not entirely completed, but so far tentative arrangements have been made for eleven of these meetings. These will include addresses as follows: by Charles Whiting Baker on a Public Service subject; Industrial Ventilating Equipment, by J. Irvine Lyle; Use of Cast Iron in Reinforced Concrete, by A. G. Hillberg; Heating and Ventilating of Street Cars or Air Conditioning with respect to Humidity Control and Removal of Dust in Industrial Plants, by Prof. R. C. Carpenter; Interesting Features of Construction involved in the Design of the Conners Creek Plant of the Edison Illuminating Company, by C. F. Hirschfeld; Recent Developments in Steam Turbine Engineering, by Prof. J. A. Moyer; Recent Progress in Bridge Design and Construction, by Prof. Henry R. Jacoby; Machine Design and Construction, by Prof. Dexter S. Kimball, etc.

AMENDMENT TO THE CONSTITUTION

The following amendment to the Constitution is to be presented at the Annual Meeting, December 1914:

C 45 The Standing Committees of the Society to be appointed by the President shall be:

Finance Committee
Committee on Meetings
Publication Committee
Membership Committee
Library Committee
House Committee
Research Committee
Public Relations Committee
Committee on Constitution and By-Laws
Committee on Standardization

The Committee on Standardization which it is thus proposed to add to the Standing Committees of the Society will act as a clearing house for all questions of standardization which come before the Society.

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i. e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility

of receiving these candidates into the Membership by advising the Secretary promptly of anyone whose eligibility for membership is in any way questioned. Members will be furnished with complete records of any candidate thus questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before October 10, 1914.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

BARNUM, THEODORE P., Secy., Barnum Brothers Co., Troy, N. Y.

BEENER, FRANKLIN, Draftsman in Charge, Bethlehem Steel Co., South Bethlehem, Pa.

BENDA, HARRY R., Mech. Engr., D. Auerbach & Sons, New York.

BIRCH, G. BIRGER, Secretary, Cameron Machine Co., Brooklyn, N. Y.

CAUGHELL, JEWEL N., Ch. Engr., Dodge Bros., Detroit, Mich.

CORBETT, ELLSWORTH A., Engr., Power House Equipment, American Mechanic Bldg., Trenton, N. J.

DANIEL, ALLAN P., Ch. Designing Mech. Engr., Bituminized Road Co., Kansas City, Mo.

DEINERT, EDMUND F., Ch. Engr. of Pumping Plants, Hawaiian Commercial & Sugar Co., Puunene, Maui, T. H.

GIBBONS, JAMES O. G., Asst. in Engrg. Dept., The New York Edison Co., New York.

JONES, IRLEY E., Secy. & Genl. Mgr., The Brownell Co., Dayton, Ohio.

KERR, ROBERT C., Draftsman and Designer, Sargent & Lundy, Chicago, Ill.

KNOEPPEL, CHARLES E., Cons. Engr., 15 Dean St., Worcester, Mass.

LANDGRAF, FREDERICK K., Genl. Supt., Flannery Bolt Co., Pittsburgh, Pa.

LEVERTON, ERNEST R., Contractor & Mgr. of Elevator Co., Calgary, Canada.

MCKIBBIN, FREDERICK W. J., President, Tompkins Bros. Co., Troy, N. Y.

MACMARTIN, JAMES MACGREGOR, Ch. Engr., The Delaware & Hudson Co., Albany, N. Y.

MORLAN, WILBERT, Engr., Pumping Station, Queens County Water Co., Far Rockaway, N. Y.

MORRISON, WILLIAM S., Ch. Mech. Draftsman, N. Y. Edison Co., New York.

MOULTON, SETH AUGUSTINE, Partner, Sawyer & Moulton, Cons. Engrs., Portland, Me.

NAKAI, KUMATARO, Engr., Ashio Copper Mines, The Furukawa & Co., Ashio, Shimotsuke, Japan.

PARKE, PETER, Ch. Engr., The Pullman Co., Chicago, Ill.

PATRICK, L., Ch. Engr., Consolidated Press & Tool Co., Hastings, Mich.

RENWICK, EDWARD B., Real Estate & Corporation Management, Pirsson & Renwick, New York.

ROYER, THOMAS J., Asst. Supt., Generation & Transmission, Pacific Lt. & Pwr. Corp., Los Angeles, Cal.

SCHMIDT, ARTHUR A., Mech. Engr., Western Precipitation Co., Los Angeles, Cal.

TIETZE, WILLIAM, Ch. Engr. of Power Plants, Pierce Phosphate Co., Pierce, Fla.

TURNER, FRANK C., Representative, Southern Wheel Co., Birmingham, Ala.

TYSON, ROBERT E., Pres., Tyson Bros., Inc., Carteret, N. J.

WOLFE, HENRY G., Asst. Leading Mech. Draftsman, N. Y. Edison Co., New York.

WOOD, DENNISTOWN, Asst. Mech. Engr. & Engr. of Tests, Southern Pacific Co., San Francisco, Cal.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

BARUCH, MILTON, Mech. Engr., Llewellyn Iron Wks., Los Angeles, Cal.

BASS, WILLARD J., Erecting Engr., Armour & Co., Chicago, Ill.

BLAKESLEE, DORAF W., Designer, Engrg. Dept., Mathews Gravity Carrier Co., Ellwood City, Pa.

BUCK, TURNEY E., Tool Designer, Sangamo Electric Co., Springfield, Ill.

COLLINS, RICHARD C., Mech. Engr., United Shoe Mchy. Co., Beverly, Mass.

CRAGG, WALSTON S., Asst. Mech. Engr., Hollinger Gold Mines, Ltd., Timmins, Ont., Canada.

DANIELS, GEORGE C., Supt. Pwr. Plant, Central Ill. Lt. Co., Peoria, Ill.

DELEMOS, SIDNEY P., Mech. Engr., Bureau of Public Bldgs. & Offices, Borough of Manhattan, New York.

FISCHER, CHARLES L., Motive Power Inspr., Pennsylvania Lines West of Pittsburgh, Pittsburgh, Pa.

PARSONS, FREDERICK A., Mch. Draftsman, Cincinnati Milling Mch. Co., Cincinnati, Ohio.

WILLIAMS, IRA L., Avon, Minn.

WORBOIS, HOMER L., Gas Engr., Bullock Tractor Co., Chicago, Ill.

FOR CONSIDERATION AS JUNIOR

ALDEN, JOHN L., Representative, Oneida Steel Pulley Co., Oneida, N. Y.

ANDERSON, ROBERT E., Junior Mech. Engr., U. S. Corps of Engrs., Cincinnati, Ohio.

BAIRD, JAMES T., JR., 56 Ellsworth Ave., New Haven, Conn.

FORSYTH, JAMES M., Student Apprentice, Allis-Chalmers Mfg. Co., Prairie Du Sac., Wis.

HOSMER, FRED E., Asst. Mech. Engr. and Draftsman, Gulf Pipe Line Co., Beaumont, Texas.

MAINE, HARRY H., 27 Bandman Ave., Jamaica, N. Y.

MUDGE, STERLING W., Engr., Arbuckle Bros., Brooklyn, N. Y.

POTTER, MARK H., Ch. Engr., Oxford Motor Cars & Foundrys, Ltd., Montreal, Canada.

RAHNER, MAXWELL L., 306 Grand Bldg., Atlanta, Ga.

SHAW, JOHN E., with International Steam Pump Co., New Orleans, La.

SHIRLEY, JOHN G., Student's Course, The Chapman Valve Mfg. Co., Indian Orchard, Mass.

SIMMONS, HARRY M., 84 North Pearl St., Albany, N. Y.

STOWELL, HOWARD E., Draftsman, The Carborundum Co., Niagara Falls, N. Y.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE

CROGHAN, JOHN T., Supt. of Constr., Stone & Webster Engrg. Corp., Boston, Mass.

PROMOTION FROM JUNIOR

WEBSTER, LAWRENCE B., Engr. on Valuations, American Gas & Elec. Co., N. Y., and Engr., Committee on Appraisals, Ohio Elec. Lt. Association, Cleveland, Ohio.

WILDER, SYLVANUS W., Supt., Dolphin Jute Mills, Paterson, N. J.

SUMMARY

New applications	55
Applications for change of grading	
Promotion from Junior	2
Promotion from Associate	1
Total	58

POWER DEVELOPMENT AT THE HIGH DAM BETWEEN MINNEAPOLIS AND ST. PAUL

BY ADOLPH F. MEYER,[1] ST. PAUL, MINN

Non-Member

The project for the improvement of the Mississippi River between Minneapolis and St. Paul had its inception in 1866. No definite action was taken, however, until 1894, when plans were developed for two locks and dams of about 13-ft. lift each, one at the site of the present High Dam, and another about three miles above the High Dam, near the Selby Avenue Bridge.

Work was commenced on the upper dam, known as dam No. 2. After about $750,000 had been spent, in the days when dry concrete was the order of the day and Portland cement was a luxury that could be advantageously diluted with ground sand, the proposition of utilizing the fall in the Mississippi River in this vicinity for power development received the attention of a special board of U. S. Army engineers, in 1907. This board reported that no power could be economically developed at the proposed 13-ft. dam No. 1, at the site of the present High Dam; that a small plant might be installed at dam No. 2; but that the probable saving estimated at $2000 per annum which would result from a 1300-h.p. development would not warrant the carrying out of the project.

This board predicted, however, that before many years had elapsed it would be economically desirable to build a high dam in the vicinity of the proposed Low Dam No. 1, which is the site of the present High Dam, where a head of probably 35 ft. might be secured, and a total of 15,000 to 20,000 h.p. developed.

The matter of power development was temporarily dropped until 1910 when a report was made by a second board of U. S. Army engineers favorable to the construction of the High Dam. The sentiment of the board as well as of the community was in favor of coöperation with the cities of Minneapolis and St. Paul and both cities passed resolutions pledging themselves to pay the additional cost of raising the projected navigation dam to a height of approximately thirty feet to permit the development of water power.

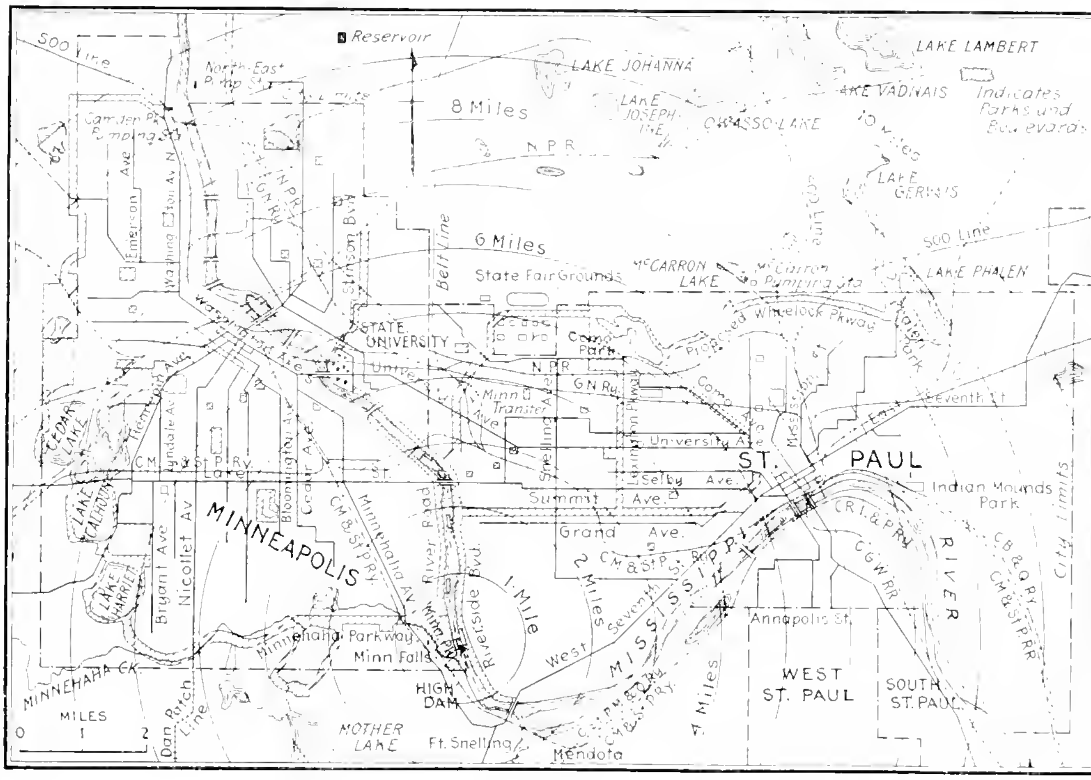

Fig. 1 Map of Minneapolis and St. Paul showing Location of the High Dam

The Board of Engineers for Rivers and Harbors concurred in the recommendations of the Special Board and the Chief of Engineers recommended that negotiations be entered into whereby the municipalities

[1] Consulting Engineer, 1000 Germania Life Bldg.

Presented at the Spring Meeting, at St. Paul-Minneapolis, 1914, of The American Society of Mechanical Engineers.

of Minneapolis and St. Paul would become the lessees of any surplus power that might be created.

In the River and Harbor Act of 1910 Congress adopted the modified project as recommended by the Chief of Engineers, with the provision "That in the making of leases for water power a reasonable compensation shall be secured to the United States, and the rates as fixed shall be subject to revision by Congress."

At the following session of the Legislature of Minnesota a bill was passed permitting the formation of public corporations for the purpose of developing water power. Under this act there was immediately incorporated the Municipal Electric Company, composed of the State University and the cities of Minneapolis and St. Paul.

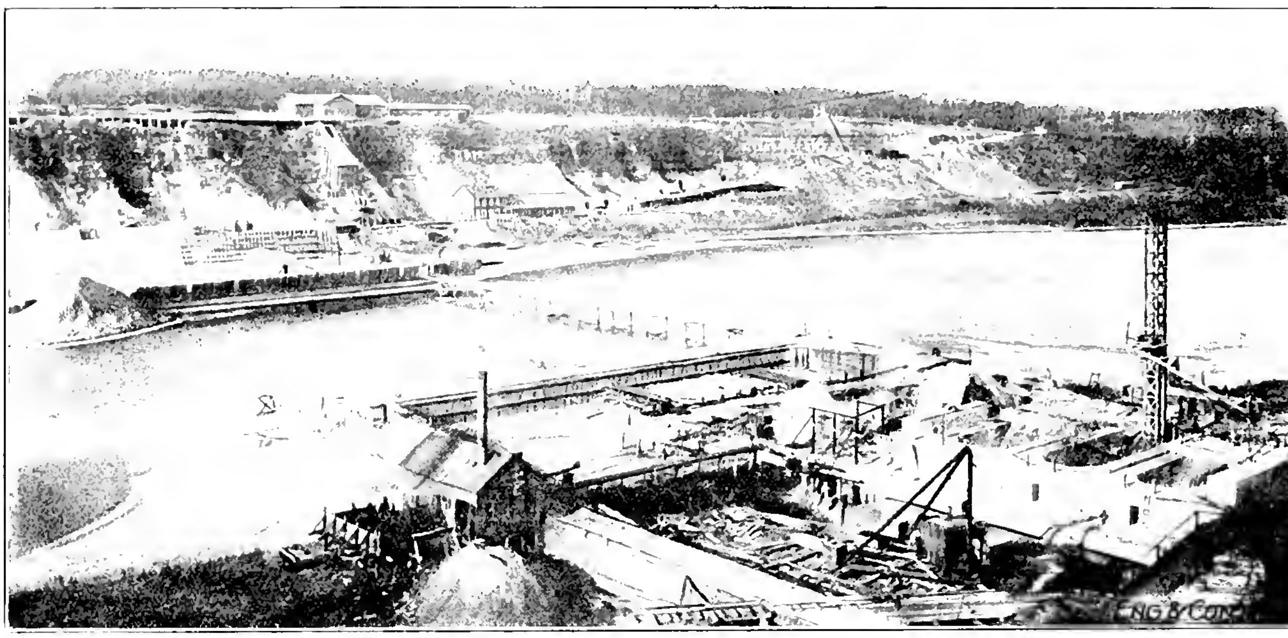

Fig. 2 Site of Dam No. 1, Known as High Dam, Across the Mississippi, Between Minneapolis and St. Paul

In 1913 a bill was introduced in Congress by Hon. F. C. Stevens, providing for a coöperative agreement with the cities of Minneapolis and St. Paul and the State University, whereby, if it becomes a law, the Municipal Electric Company may lease the available water power upon the condition, among other things, that this company pay not less than 3 per cent interest on the amount which the government will have expended for the purpose of making the water power available.

AVAILABLE POWER

The amount of water power which will become available through the construction of the High Dam can be ascertained with considerable accuracy, inasmuch as good physical data are available.

Estimates of stream flow have been made by the St. Anthony Falls Water Power Company and the Minneapolis Mill Company at their plants in Minneapolis, covering a period of more than 20 years. In the more detailed analysis of available power which was made, however, the records kept by the U. S. Engineer office at St. Paul, during the eight years from 1905 to 1912 inclusive, have been used.

The diagram in Fig. 9 shows graphically the elevation of "tail water" and "head water" at the various rates of discharge. The head water curve gives elevations one foot below the maximum permissible elevation as computed, to which the water above the dam can be raised without producing backwater at the lower power dam in Minneapolis. The present dam is being constructed with its crest at an elevation of 743.5 Cairo datum. The tail water curve gives the mean elevation of the water surface for various rates of discharge, based on the readings of the government gage at the site of the dam during the past eight years, taking into account the lowering of the tail water which will result from dredging a 6-ft. channel below the lock, the backwater from the Minnesota River at flood stages, and backwater from ice conditions in the winter.

The head curve gives the mean head which would be available on the assumption of three feet of flashboards on the dam at low water, and a turbine installation capable of using about 5000 cu. ft. per second. It will be noticed that the head varies from a maximum of $36\frac{1}{2}$ ft. at low water to a minimum of 22 ft. during extreme flood conditions, such as might occur for a few days perhaps once in ten years. The normal head may be assumed as 34 ft. For perhaps twenty days a year on an average, or $5\frac{1}{2}$ per cent of the time, the available head will be reduced during high water to less than 29 ft.

Water Available. Table 1 gives the mean monthly stream flow at the dam site for the years 1905 to 1912 inclusive. It will be noticed that the mean monthly

TABLE 1 MEAN MONTHLY DISCHARGE
1905–1913

	1905 c.f.s.	1906 c.f.s.	1907 c.f.s.	1908 c.f.s.	1909 c.f.s	1910 c.f.s.	1911 c.f.s.	1912 c.f.s.	1913 c.f.s.
Jan	3174	6667	6220	2390	3350	4198	1764	1840	2600
Feb........	2745	6280	6250	2750	3300	4011	1799	1750	2200
Mar........	5241	7320	11600	4550	4300	9470	2338	2140	2880
Apr	9775	24653	25099	8185	11721	8640	3404	7080	5125
May	21013	20227	13673	13300	11910	6280	4688	16080	7850
June........	23749	29090	18681	32079	11950	4330	4762	7240	6015
July........	31762	16525	8266	14364	6160	*3500	3719	5280	8950
Aug.........	15700	9185	7347	6992	8570	*3400	3400	5100	6255
Sept........	12874	10965	7149	5100	6480	*3800	3588	5020	5990
Oct.........	11067	11378	7674	5980	5420	3210	4351	4840	......
Nov........	9743	11301	7715	5070	5350	2690	2712	3840	......
Dec........	8163	6980	3310	3800	5120	2010	2355	2890	......
Mean Annual...	12920	13390	10250	8710	6965	4630	3240	5260	......

* Modified on basis of Anoka discharge.

flow is below 2000 cu. ft. per second for four months in eight years. The minimum mean monthly flow is 1750 cu. ft. per second. In computing the minimum amount of power which would become available at the dam, an extreme minimum flow of 800 cu. ft. per second has been assumed. Such a flow, however, has in the past occurred for only a portion of a day during

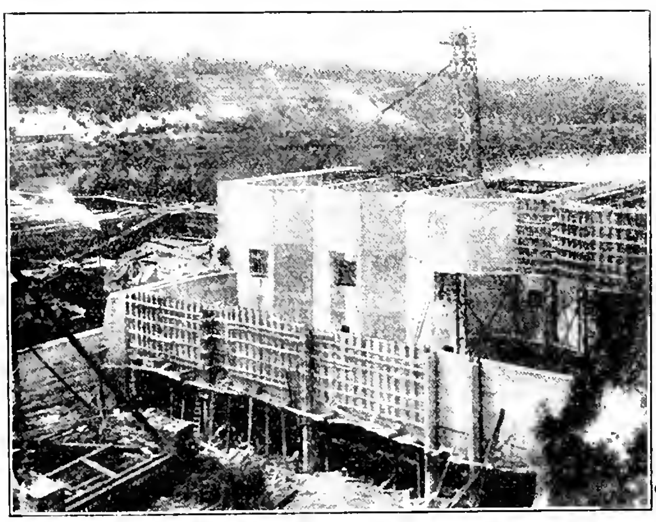

Fig. 3 Construction View of Power House, July 1913

sudden periods of extremely cold weather. On such occasions the normal flow of 1500 to 2000 cu. ft. per second is usually re-established in two or three days. A minimum winter flow has been assumed as follows: 800 cu. ft. per second for one day; 1300 cu. ft. per second for three days; 1500 cu. ft. per second for five days; and 1750 cu. ft. per second for one month.

Effect of Pondage. The area of the pool above the dam at the 740 contour has been determined by planimeter measurements on recent government maps to be 22,500,000 sq. ft. Assuming the pool to be full to the top of the flashboards at the approach of an extremely cold spell, the water surface would be lowered 4.2 ft. in order to augment the supply from 800 cu. ft. per second for one day, and 1300 cu. ft. per second for two additional days, to a mean of 1500 cu. ft. per second. As the available head, in winter, would be at least 36½ ft., the net head which would remain available after drawing down the pool would still be 32.3 ft. By operating the steam pumps to provide the municipal water supply for Minneapolis and St. Paul, or by drawing upon the supply stored in the reservoirs, or both, the station load can be sufficiently reduced to enable the pool to fill again in two or three days.

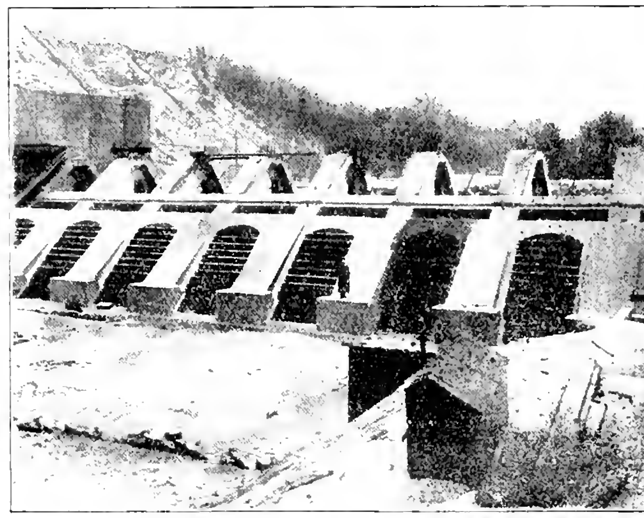

Fig. 4 View of High Dam, January 1914

Power Available. Table 2 gives the number of days per year during which certain amounts of power in blocks of 1000 kw. would have been available for each year from 1905 to 1912 inclusive. A flow of 1750 cu. ft. per second corresponds to about 4000 kw. at the switchboard, assuming an overall efficiency of 75 per cent; 1500 cu. ft. per second under 32.3 ft. head corresponds to about 3100 kw. This is the maximum amount of power which could be counted on with positive certainty 24 hours of the day, and every day in the year.

ECONOMICAL SIZE OF INSTALLATION

The desirability of utilizing, for power development,

TABLE 2 NUMBER OF DAYS PER YEAR CERTAIN AMOUNTS OF POWER WOULD HAVE BEEN AVAILABLE
1905–1912

Year	1000 kw.	2000 kw	3000 kw.	4000 kw	5000 kw	6000 kw.	7000 kw.	8000 kw.	9000 kw.	10000 kw.	10500 kw.
1905...........	365	365	365	365	365	365	365	365	353	326	297
1906	365	365	365	365	365	365	365	365	365	342	317
1907	365	365	365	362	349	332	322	288	262	261	243
1908	366	366	366	366	366	363	349	303	270	227	180
1909.........	365	365	365	365	365	365	357	340	305	266	165
1910	365	365	365	363	290	262	215	133	113	104	91
1911	365	365	365	362	307	244	202	142	90	45	25
1912	366	366	366	363	329	273	256	211	228	203	140
Total.	2922	2922	2922	2911	2736	2569	2429	2175	2085	1873	1456
Mean	365	365	365	364	342	322	304	272	261	234	182
Per cent ..	100	100	100	99.8	93.7	88.2	83.4	74.5	71.5	64.3	50
Mean deficiency (days)......	.	.	. .	1	23	43	61	93	104	131	183

water which is available for only a portion of the year, is dependent mainly upon the relative cost of producing power by steam plants and by water power plants.

If the cost of operating a given steam power plant a certain number of hours a day for the portion of the year during which additional water is available is greater than the fixed charge would be on the additional water power installation, plus the cost of operating this additional installation for that portion of the year, it would pay to develop such power.

The curves in Fig. 10 are based on the following assumptions: The Federal Government will have invested

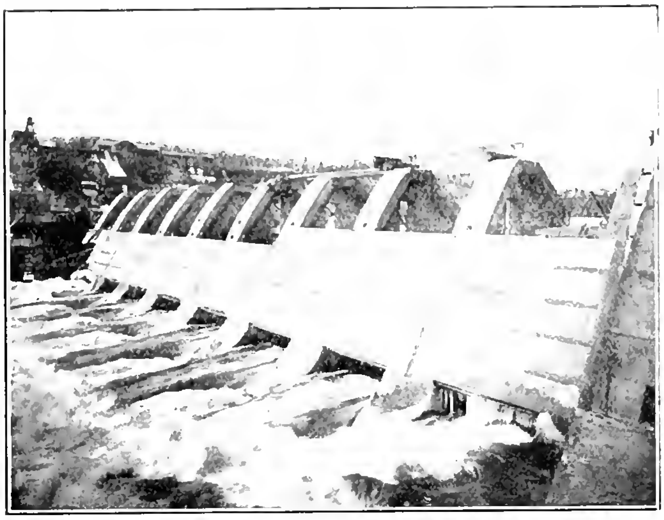

FIG. 5 VIEW OF HIGH DAM, MARCH 1911

about \$800,000 in a modification of the navigation project, to provide for the utilization of water power, consequently the fixed charges on this amount must be borne by whichever size of installation is adopted. It will at once be apparent that the larger the installation, the less the fixed charge per horsepower will be. This, of course, is true only within reasonable limits, as the draft tubes have already been built, and hence the friction and other losses resulting from the discharge of larger quantities of water by a larger turbine installation will lower the efficiency of the plant.

A detailed estimate of the total cost of an installation necessary to develop about 15,200 h.p. is made later in this paper. The government investment amounts to \$52.50 per h.p. and the additional cost of installation will amount to about \$41.50 per h.p., or \$60 per kw.

The estimated fixed charge for each additional kilowatt of capacity of water power installation is made up of the following items:

$4\frac{1}{2}$ per cent interest on \$60.00	\$2 70
Sinking fund.	0 40
Depreciation (or renewal fund)	3 00
Annual fixed charge	\$6 10

The cost of operation for the additional water power installation is estimated at \$3 per kw. per year. The cost of operation for the steam plant is on the basis of large modern units. Plants of 25,000 to 50,000-kw. capacity, using large units and operating on a 50 per cent load factor, can produce electrical energy at an operating cost of about 0.45 cent per kw-hr. This is equivalent to a total cost of about \$28 per kw. per year for 12-hour power.

It would appear from the curves in Fig. 10 that the cost of furnishing 8-hour power by a large steam plant would be the same as the cost of furnishing such power by a hydroelectric plant, using water available 58 per cent of the time. The cost of 12-hour steam power would just equal the cost of hydroelectric power produced from water available 37 per cent of the time. As the ordinary commercial light and power loads have a load factor averaging between 35 and 50 per cent, it would appear desirable to install a plant capable of using all the water which would, on an average, be available for at least 40 per cent of the time, provided the owner of the water power possessed a large steam plant.

If the Municipal Electric Company undertook to

FIG. 6 VIEW OF FOREBAY, FEBRUARY 1911

develop this power, however, it would either have to sell, in the open market, any surplus power not required for public purposes, developed from water available for only a portion of the year, or else install a steam auxiliary. If it sold the excess power in the open market to consumers who were developing their own power by a large steam plant, it could not expect to receive more than about 75 per cent of what this power might be worth to said consumers.

On this basis, power developed from water available 50 per cent of the time might just find a market with consumers who were developing 12-hour steam power. When available at all, such excess power could be furnished at any time of the day, and for 24 hours if necessary, but it would have to be either utilized or wasted, as the water could not be stored. Ample notice, however, could be given consumers.

On the above assumptions, it would appear advisable to install a plant of 10,500-kw. capacity, inasmuch as this amount of power would be available for at least 50 per cent of the time, according to Table 2, smaller amounts being available, of course, for longer periods.

In case the company installed a steam auxiliary plant to supply power on days when the necessary water was not available, so that the power from the combined source could be furnished any hour of the day and every day of the year, the fixed charge would have to be paid on the combined installation, and the total cost of furnishing such power would again depend upon the per cent of time the water was available.

It is assumed that the steam auxiliary power plant would have a capacity of about 5000 kw. and would cost \$90 per kw. The fixed charge is assumed as 9.8 per cent, or \$8.80 per kw. per year, composed of the following items:

Interest. . .	4.5 per cent
Sinking fund	0.5 per cent
Depreciation (or renewal fund)	4.8 per cent
Total fixed charge.	9.8 per cent

The fixed charge on the additional water power installation is assumed as \$6.10 per kw. per year, in accordance with the detail estimate previously given.

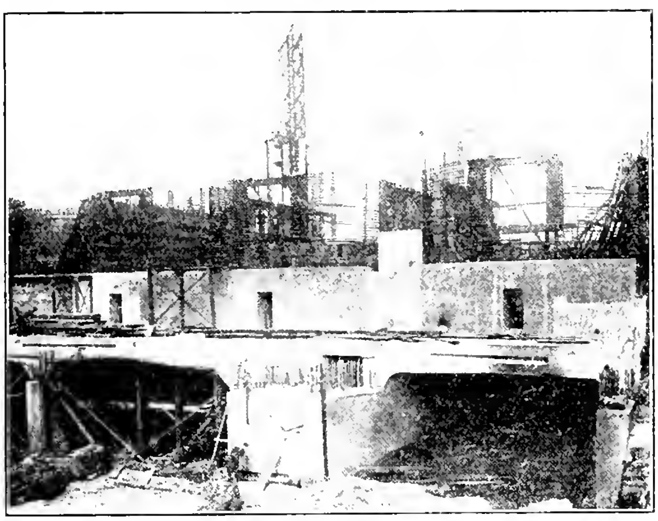

FIG. 7 CONSTRUCTION VIEW, FEBRUARY 1913, SHOWING TAIL RACE

Power from such a combined source would have to compete with power produced by large steam plants, if not utilized by the Municipal Electric Company itself. It would appear from the curves, Fig. 11, that water would need to be available 84 per cent of the time in order to bring the cost of combined power down to the cost of 8-hour steam power produced by large plants. For water available 75 per cent of the time, the cost of combined power would just equal the cost of 12-hour steam power, and for water available 70 per cent of the time, the cost would just equal 16-hour steam power. The cost of 24-hour power developed by such a combined plant using water available less than 64 per cent of the time, would be greater than the cost of 24-hour power developed by a large steam plant.

Considering the cost of connecting up, by pole line or conduit, to some large plant, and of the difference between cost and market price of power, it is probable that the Municipal Electric Company could not purchase even large blocks of peak power at less than 0.9 cents per kw-hr. for 12-hour power. On this basis it would just pay to install turbines capable of developing water power which would be available at least 50 per cent of the time, and to add a 5000-kw. steam auxiliary plant when the Municipal Electric Company's own demands for power warranted such installation.

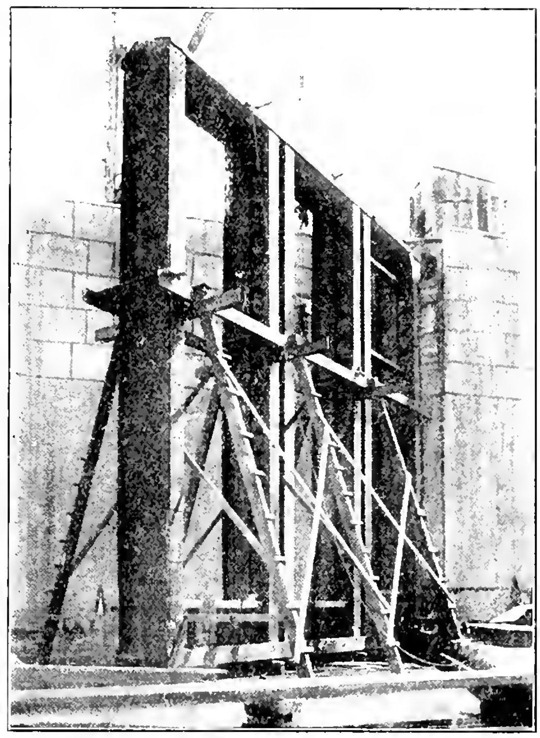

FIG. 8 LOCK AND GATE, APRIL 1913

INSTALLATION PROPOSED

The great reduction in head during high water makes it necessary to install a plant of very much greater turbine capacity than would be necessary under more uniform head conditions. At times of high water there is not only a reduction in the available head, but also a reduction in the amount of water which any given turbine installation is capable of utilizing. As the discharge from turbines varies with the square root of the head, any given turbine installation at the High Dam operated at a certain gate opening will be able to discharge only about eight-tenths as much water under flood conditions as under low water conditions.

On the basis of Holyoke test data, a preliminary study was made of the probable performance of turbines of the size which it will be necessary to install in order to develop the contemplated power, operating

under the conditions which will obtain at the High Dam, i.e., under a head varying from 36.5 ft. at low water to 22 ft. at extreme flood stage. After this preliminary study had been made, it appeared desirable tentatively to recommend the installation of four units having a rated capacity at full gate under low water head of about 5000 h.p. per unit; either one or two runners to be used on each shaft and the turbines to be direct-connected to 3500-kva. generators. Even this installation, however, would be capable of developing only about 7000 kw. at extreme high water. Very good efficiencies would be secured under heads ranging from

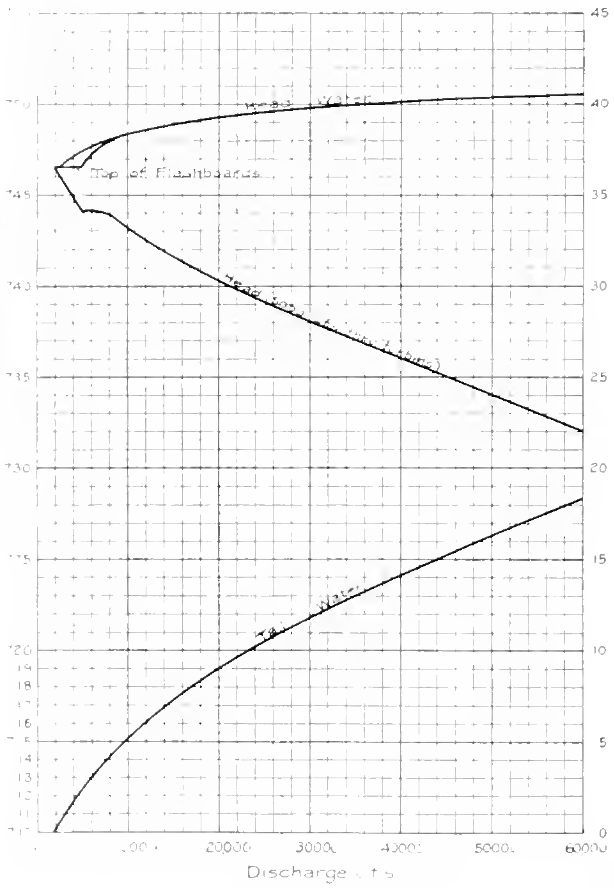

FIG. 9 ELEVATION OF TAIL WATER AND HEAD WATER AT VARIOUS RATES OF DISCHARGE

32 to $36\frac{1}{2}$ ft. when operating such turbines at from 65 to 90 per cent gate opening. Four units would carry the normal station load of 10,500 kw. when operating at about 72 per cent gate opening and under a 34-ft. head. Such an installation would also be capable of developing 10,500 kw. during ordinary flood conditions, under a 29-ft. head, when all four units were operated at approximately full gate opening. Three units at full gate opening under low-water head, with only a small overload on the generators, depending on the power factor, would also be capable of developing 10,500 kw.

It is believed that the rather large installations would be fully warranted by the conditions under which this plant would be required to operate. While the full rated capacity of the plant at low water and under full gate might be considered as 20,000 h.p., the normal capacity would really be only about 15,200 h.p., inasmuch as it would be poor policy not to have a reserve unit under ordinary conditions of head, stream flow, and load.

PROBABLE COST OF DEVELOPING THE WATER POWER

The Federal Government has practically completed the modified project in accordance with the Act of Congress of 1910, and the United States Engineer Office at St. Paul has estimated that the total cost of the project, as modified for the development of water power, including the construction of the power house substructure, draft tubes, etc., will be $800,000 more than the cost of the original project would have been.

In the Stevens bill now pending in Congress, it is provided that the Municipal Electric Company pay not

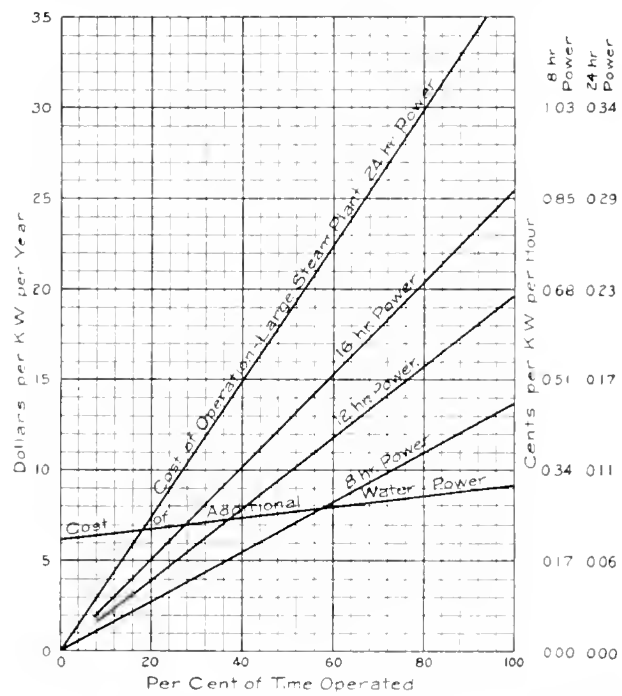

FIG. 10 COST OF OPERATING STEAM, AND FOR ADDITIONAL WATER POWER, FOR DIFFERENT TIME PERIODS

less than 3 per cent interest on the amount which the Government has invested for the purpose of making the water power available. For an installation of 15,200 h.p., the Government investment amounts to about $52.50 per h.p.

Additional Expenditure Required. In order to complete the power house and install the necessary machinery, an additional expenditure of about $630,000 will be required. This includes interest during construction, insurance, engineering, supervision, and contingencies, and $50,000 working capital or "emergency fund," required by the laws of Minnesota under which the Municipal Electric Company is incorporated.

Adding the Government expenditure of $800,000 gives $1,430,000 as the investment cost of the plant.

This amount is equal to about $94 per h.p. at the turbine shaft, and $136 per kw. at the switchboard.

Fixed Charges and Operating Expenses. The fixed charges on the water power plant will be about as follows:

3 per cent interest on $800,000, per annum	$24,000
$4\frac{1}{2}$ per cent interest on $630,000, per annum	28,100
Sinking fund to pay off $630,000 in 50 years at 4 per cent	4,050
Renewal of plant in 15 years at 4 per cent	31,460
Maintenance	10,090
Total fixed charges	$98,000

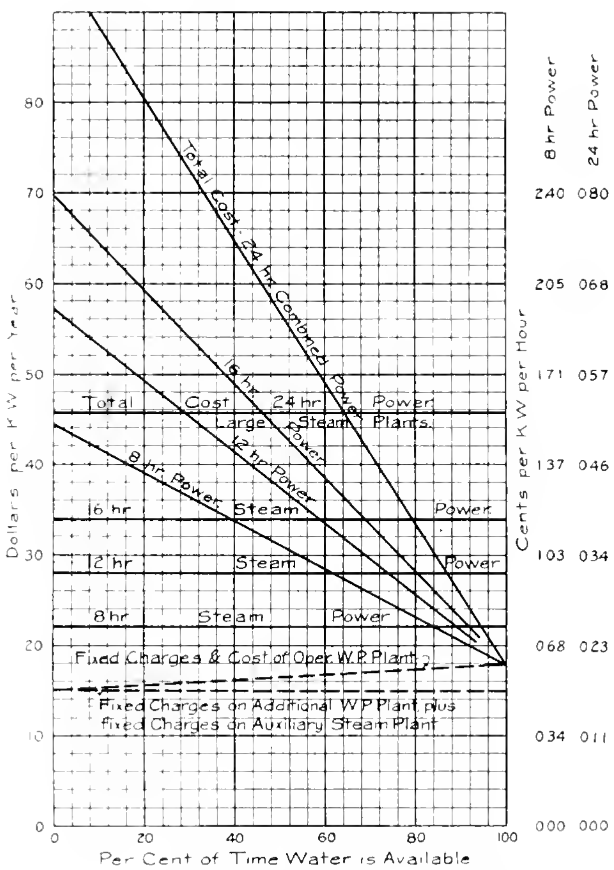

FIG. 11 COST OF COMBINED POWER FOR DIFFERENT PERIODS

Adding to the fixed charges the annual cost of operation and administration, including an allowance for the annual charge on the investment in transmission lines and substations not herein itemized, brings the total cost of developing power to about $150,000 to $175,000 per annum.

Cost of Power per Kw-Hr. According to Table 2, the mean annual deficiency of power up to 6000 kw. is 1,608,000 kw-hr. Assuming that the steam pumps would be operated to supply this deficiency, all power up to 6000 kw. may be considered as primary power as far as the Municipal Electric Company is concerned. The mean annual amount of such power which would have been available during the past 8 years is, on the basis of Table 2, 50,800,000 kw-hr. The total amount of power between 6000 kw. and 10,500 kw., which would have been available during the same time, is 27,900,000 kw-hr., or a total of 78,700,000 kw-hr. of available power per annum. This is equivalent to a mean of 9000 kw., and on this basis the cost of developing 24-hour power would be a trifle less than two tenths of a cent per kw-hr.

If we assume that the power which could not be furnished at all times—the "excess power"—is worth, on an average, one-third as much as the "primary power," there would be an average of 60,100,000 kw-hr. of power available each year. This would make the cost of developing power about a quarter of a cent per kw-hr. If a 5000-kw. steam auxiliary plant were installed so as to make 10,500 kw. available at all times, the cost of developing this power would be about 0.35 of a cent per kw-hr. on the basis of 24-hour power.

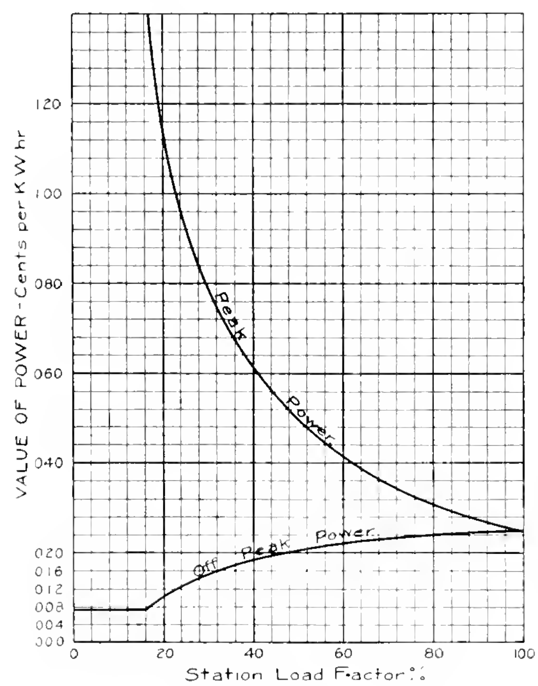

FIG. 12 RELATIVE VALUES OF PEAK AND OFF-PEAK POWER FOR DIFFERENT LOAD FACTORS

Fig. 12 shows the relative values, at the station, of "peak" and "off-peak" power for different load factors, on the basis of a cost of a quarter of a cent per kw-hr. for continuous power. If the load factor of the station for any given load were very small, as, for example, in the neighborhood of 20 per cent, off-peak power could be sold at the mere additional cost of operating the water power plant. This would be, in the case under consideration, less than one-tenth of a cent per kw-hr. As the load factor became larger, the value of off-peak power would approach that of peak power, equaling it when the load factor became 100 per cent, and at all times possessing a value about inversely proportionate to its effect in increasing the load factor. The peak power, in order to yield a return

equivalent to a quarter of a cent per kw-hr. for continuous power, would be worth about one and one-fourth cents per kw-hr. at 20 per cent load factor, taking into consideration the slightly lower cost of operation in the case of power furnished for only a small portion of the day, but without taking into consideration the compensating effect of pondage, i.e., assuming that the available water must be either utilized or wasted.

With a station load factor of 60 per cent, under the same assumptions, the value of peak power at the station would be about four-tenths of a cent per kw-hr., and off-peak power would be worth just about half this amount.

When the effect of pondage is taken into consideration, however, the load factor is found to affect the cost conditions assumed, less than 10 per cent. Not until the amount of water continually available has increased to 4500 cu. ft. per sec., or peak load conditions, will the value of power be increased $2\frac{1}{2}$ fold by a 40 per cent load factor.

UTILIZATION OF POWER

Present Consumption. Statistics were obtained, from all available sources, giving the amount of power at present consumed by the Federal Government, the State of Minnesota, and the cities of Minneapolis and St. Paul, for what might be called public purposes. These quantities are graphically shown by months in Fig. 15.

It is apparent that the city of Minneapolis is using more power than the Federal Government, the State of Minnesota, and the city of St. Paul together. The

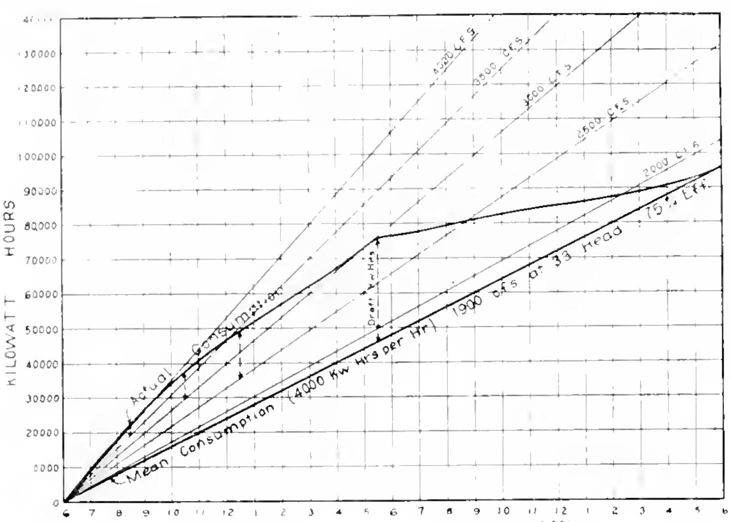

Fig. 13 Mass Curve of Consumption

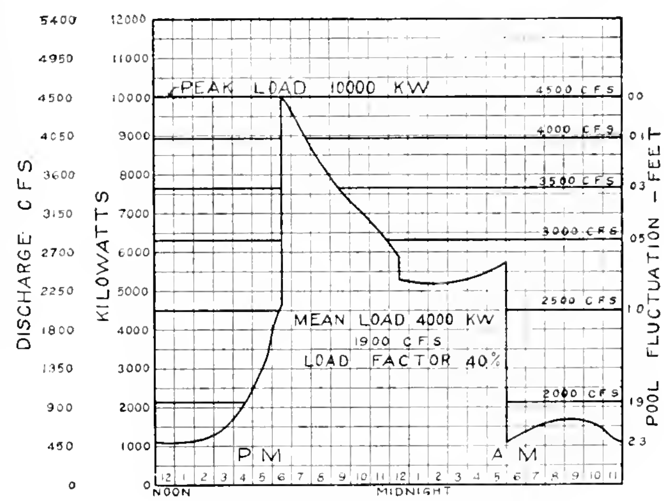

Fig. 14 Typical Load Curve

of power considerably less than the value of that factor would make it appear. In Fig. 14 is shown a characteristic combined street lighting and miscellaneous light and power load, having a load factor of 40 per cent. Fig. 13 shows a mass curve of actual consumption of current and of mean consumption, or equivalent in supply of water, from which can be scaled the quantity of power which must be furnished by stored water for various mean rates of stream flow. From this value, the area of the pond, and a mean head for each particular condition, the pool fluctuation for various rates of discharge, as shown in Fig. 14, was determined.

The only effect of the load factor, then, in this case where the entire flow of the stream was being utilized through pondage, would be due to a reduction in available head from drawing down the pool, and from a rise in the tailwater at the time of high discharge, i.e., peak load. Instead of the 40 per cent load factor having increased the cost of power $2\frac{1}{2}$ times, as indicated in Fig. 12, it has, in reality, increased the cost, under the principal reason for this is that the city of Minneapolis has recently installed motor-driven pumps for pumping its water supply. The power used by the two city halls, the street lights, the Minneapolis pumps, and the power which would be used in St. Paul for pumping, if a motor-driven pump were installed at the McCarron Lake pumping station, are also shown individually.

Station Load. Inasmuch as there is considerable loss in the transformation and distribution of electrical energy between the station and the place of consumption, the amounts consumed were reduced to their various equivalent station loads on the following basis: It was assumed that of 100 h.p. available at the station switchboard, 87.5 h.p. would be available for the pump motors, and 75 h.p. for the street lights, and for most of the miscellaneous light and power uses. The latter is equivalent to an overall efficiency of conversion from hydraulic power to electric current at point of consumption of 56 per cent, and is well on the side of safety.

Future Consumption. In estimating the probable consumption in 1920, the amounts used at present in the public buildings have been increased by 25 per cent. The present gas and gasolene street lamps in the cities of Minneapolis and St. Paul have been assumed to be replaced by electric lights in the proportion of about one arc light, or equivalent, to four existing gas or gasolene lamps. A lighting installation of 4000 arc lights and 1000 ornamental lights or equivalent, was assumed for Minneapolis, and 2700 arc lights and 600 ornamental lights, or equivalent, for St. Paul. This would practically double the present consumption of electric current for street lighting purposes in the two cities.

The future power requirements for pumping represent what will be needed in 1920, on the basis of the past few years' increase in water consumption. It represents an increase of practically 50 per cent. The future requirements of the State University are based on an approximate doubling of the present consumption.

Load Factors. The mean annual station load from the above estimated consumption of current for public purposes will be about 5500 kw. by 1920. The peak load will be about 8500 kw. and the load factor about 65 per cent. In Figs. 16 and 17 are graphically shown typical December and June station loads, planned with a view to keeping the station load factor as large as possible. By running the Minneapolis and St. Paul pumps during the off-peak hours, a December load factor, for present loads, of about 87 per cent can be secured, and for future loads, a factor of about 74 per cent can be secured. The load factor for the miscellaneous light and power load is about 44 per cent in December, and 60 per cent in June. That for the street lighting load is about 56 per cent in December and 27 per cent in June. These load factors on the whole are considerably better than those usually obtained from commercial light and power loads. During June, the present station load factor would be about 76 per cent, but the future load factor would be reduced to about 60 per cent unless the installation of motor-driven pumps in Minneapolis is increased. The present installation will soon be insufficient to supply the increased water consumption even if run 24 hours of the day. This, of course, is uneconomical, as it would result in adding the Minneapolis pump load to the peak. Before this condition is reached, however, Minneapolis no doubt will find it advisable to install an additional motor-driven pump; in fact, this is already under consideration.

The mean 1920 December station load will be about 6000 kw. This would be secured from a discharge of 2600 cu. ft. per second under the low water head. The mean 1920 June station load will be about 5200 kw.

The total amount of electrical energy which will probably be required in December 1920, for street lighting and for miscellaneous light and power purposes, measured at the station, is about 93,000 kw-hr. This amount of electrical energy would be secured from a discharge of 1650 cu. ft. per second under the low water head.

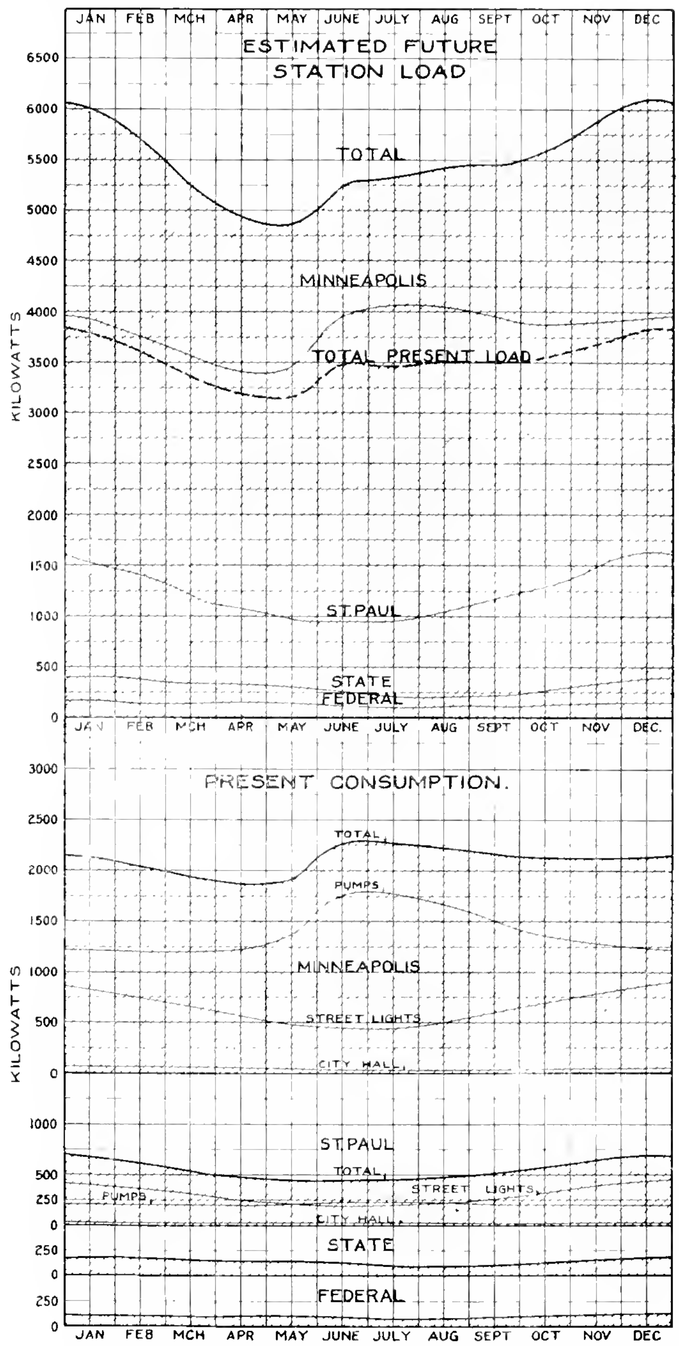

FIG. 15 PRESENT AND ESTIMATED FUTURE CONSUMPTION OF POWER IN THE VICINITY OF HIGH DAM

Use of Steam Pumps. Through proper coöperation between the cities, the State University, and the Municipal Electric Company, the existing steam pumping plants of the two cities can be made to serve economically the dual purpose of emergency pumping equipment and small auxiliary power plant. So far as the

reliability of a water supply is concerned, a combined steam and electric pumping plant is preferable to a plant dependent upon electrical power alone. So far as additional power required during periods of low water is concerned, the steam pumping plants constitute the very best small auxiliary. They can deliver water to the reservoirs at less operating cost than a 5000-h.p. steam plant, generating current which has to be transmitted and transformed, and then applied through a motor to centrifugal pumps, can possibly do. As the steam pumping plants are in existence, they serve as emergency pumping equipment and auxiliary power plant of about 2500 kw. capacity at the same time.

The reservoir storage at the Minneapolis filtration plant amounts to about 80,000,000 gal. By 1920 the daily water consumption in winter is not likely to exceed 40,000,000 gal. The Minneapolis steam pumps have a capacity of 30,000,000 gal. daily, so that in case the electrical pumps were temporarily disabled, or no current were available, the steam pumps, by running continually, would be able to furnish the additional water necessary to supply the city for 8 days. The St. Paul steam pumps have an aggregate capacity of

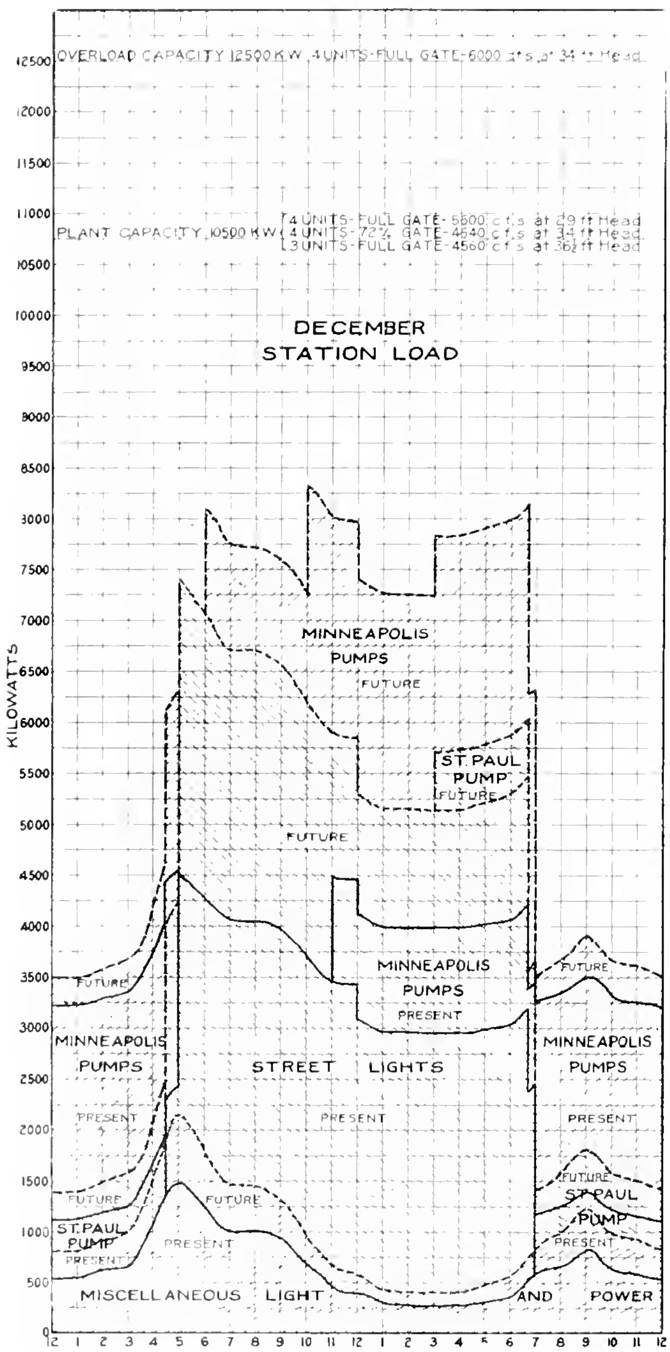

Fig. 16 Typical December Station Load for Public Purposes

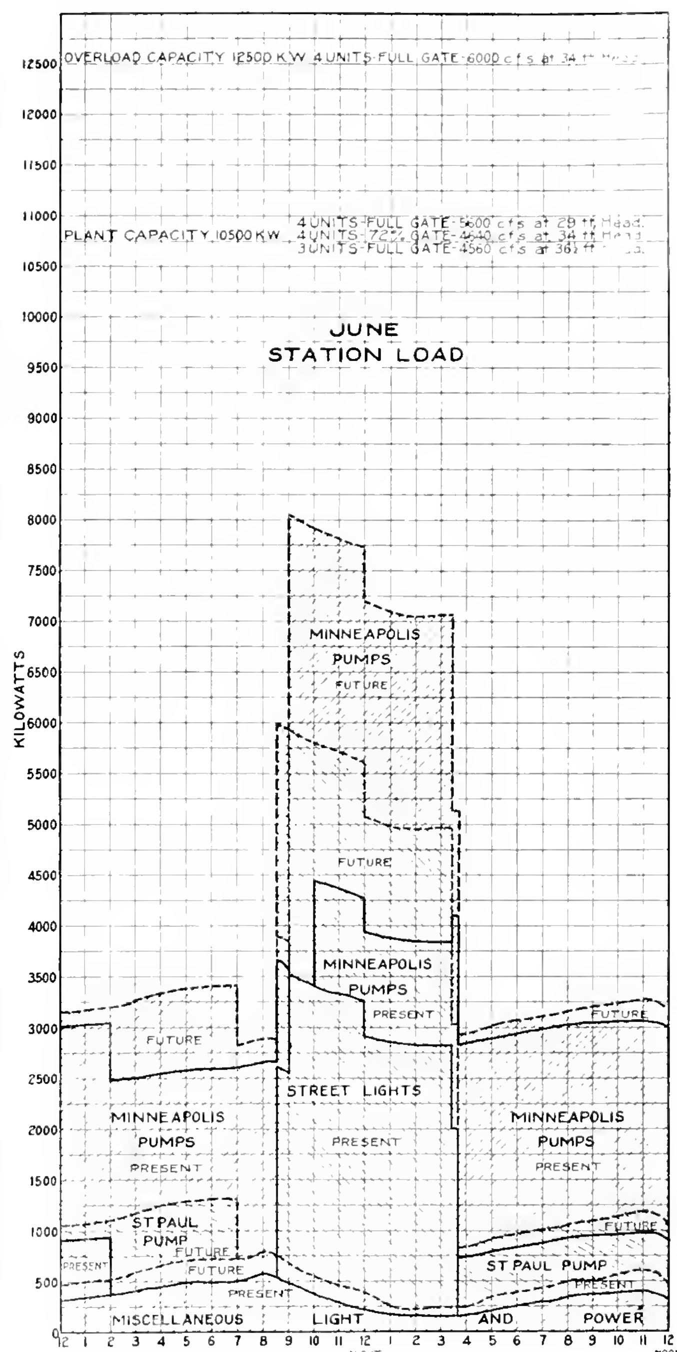

Fig. 17 Typical June Station Load for Public Purposes

about twice the present mean daily water consumption. A flow of 1750 cu. ft. per second is equivalent to about 98,000 kilowatt hours of power per day. Whenever, because of low water, the power output fell to this amount, it would be necessary to run the two Minneapolis steam pumps practically all day. Whenever the discharge fell to 2000 cu. ft. per second, it would be necessary to run these two Minneapolis pumps about 16 hours a day. It is probable that it would be necessary to run the steam pumps for at least a portion of the day, on an average 25 to 30 days a year, or 5 per cent to 8 per cent of the time. This is not entirely a disadvantage, however, as it would serve to insure the emergency steam pumping equipment of both cities being kept in good operating condition.

On the basis of statistics obtained from the 1912 report of the Supervisor of Water Works, Minneapolis, the fuel and labor cost of operating the steam pumps has been computed to be equivalent to a rate of practically one-half a cent per kw-hr. for the electric pumps. This is about half the cost of electric power developed by a small auxiliary steam plant.

As previously indicated, during extremely cold weather the maximum available 24-hour power may occasionally fall to less than 4000 kw. By utilizing the steam pumping plant for a few days each year, and drawing on the available pondage, the maximum available primary power can be raised from 3100 to about 6000 kw., and at a lower cost than could be done by a small steam power plant.

Even if, in the near future, there should be an extreme flood, such as may occur for a day or two once in 15 or 20 years, the water power plant would still be able to carry a peak of about 7000 kw. This is more than would be required for the street lights and miscellaneous light and power uses. The steam pumps could again be run for a few days to supply any deficiency.

Surplus Power. It is estimated that by 1920 the mean annual rate of consumption of power for the purposes previously outlined will be about 4520 kw., if the gas and gasolene lights are replaced by electric lights as contemplated in this paper. This is equivalent to a mean annual station load of 5500 kw. The mean December station load would be about 6000 kw., but in order to be able to meet the Municipal Electric Company's own peak load at times of high water, a very much larger installation would be required. In fact, an installation rated at 10,500 kw. under normal head and with one spare unit would furnish only very little more than the peak load which will probably have to be carried during the spring months by 1920.

Assuming, then, that the Municipal Electric Company in the near future would want to reserve for its own uses, as previously outlined, 6000 kw., there would still remain about 4500 kw. of excess power. The mean annual amount of available power will be about 9000 kw. With an installation as contemplated in this paper, it would be possible to carry a peak load for several hours of 12,500 kw. under normal head, and for one hour a peak load of about 13,500 kw. Inasmuch as the Municipal Electric Company's peak would be about 8500 kw. by 1920, it is apparent that 4000 or 5000 kw. of excess power, when available at all, could be carried over the peak. This, undoubtedly, would make the excess power of considerably greater value than if it were necessary to sell it all as off-peak power.

The installation contemplated in this paper would assure a reserve unit for use in case one of the other three units was temporarily disabled. This unit could also be put into service whenever, at times of ordinary high water, such as may occur for about a month each year, the head is reduced to a point where the three units would no longer be able to carry the load. It would also serve to make available, as peak power, the excess power, whenever such power could be furnished at all. Until the demands of the community, for power for public purposes, enable the Municipal Electric Company to utilize all of the available power, the surplus should be disposed of in such manner as would be of the greatest benefit to the public.

PROBABLE BENEFITS

The writer has made detailed estimates of the savings to the community that would result from the operation of the proposed hydroelectric plant, and places it conservatively at about $200,000 per annum by a few years after the Municipal Electric Company has begun operations.

DISCUSSION

At the time of the Spring Meeting high water in the Mississippi made it impossible for those in attendance to inspect the construction work of the High Dam. In presenting his paper, therefore, the author showed slides of the dam and power house in various stages of completion, which gave a clear idea of the work in progress. He concluded with comments on the high stage of the river and the amount of power that would be available at different levels, referring to the effect of the Government reservoirs at the headquarters of the river, which comprise the largest reservoir system for stream regulation in the world.

As a result of these remarks most of the discussion which followed centered about the effect of the reservoirs, both in relation to the use of the river for navigation purposes and the development of the power project at the High Dam. This subject is one of great magnitude and since the short time available at the meeting permitted only fragmentary discussion quite inadequate to the problem, no space has been given to a report of the discussion.—Editor.

INDUSTRIAL SERVICE WORK IN ENGINEERING SCHOOLS

BY JOSEPH W. ROE, NEW HAVEN, CONN.

Member of the Society

A social force has been at work in our engineering schools for the past few years which materially affects the attitude of students, on leaving college, towards working men. It concerns a steadily growing portion of the membership of The American Society of Mechanical Engineers, that in the Student Branches. As many of these members will be called on for leadership in this Society in the coming generation, whatever helps or hinders their broadest professional training should have its careful consideration.

In the winter of 1907-1908 some engineering students of the Sheffield Scientific School at Yale started an activity which for want of a better name, has been called industrial service work. It consisted of a study of welfare activities, living and working conditions in American industries, and a definite attempt to render some useful service to workingmen in the city. As a large industrial center, New Haven has many thousands whose greatest need is a knowledge of the English language. It was felt that to help meet this need was the most practical service the students could render. A system of instruction in English was evolved, based on the familiar phases of everyday life, which did not require a knowledge of the foreign language on the part of the teacher. Groups were organized in various parts of the city wherever they could be gathered, the general plan being that the students should go to the men rather than to attempt bringing the men to any school or institutional buildings. The plan worked well from the start. The classes were full and many newly arrived immigrants were reached who would not have come near a public night school.

In connection with this teaching work, which was the main activity, a series of talks on industrial subjects was given to the students by such speakers as John F. Stevens of the Panama Canal, S. B. Thorne of the Buck Run Coal Company, Charles Stelzle, Miss Gertrude Beeks, Prof. Edward A. Steiner, Charles R. Towson, and others. A small library on immigration and industrial conditions was set at work and some of the books became well worn.

The hold which it took on the better type of student, as well as its effect on him, were interesting and significant. The work was wholly voluntary and done in their own free time, yet many gave two or more evenings a week throughout the whole winter to it. The word "mucker" dropped from their vocabulary. The "wop," the "hunkie" and the "dago" became people, acquired names, and sometimes commanded their genuine respect. Student and workmen were coming, often for the first time, into direct and friendly contact and finding out for themselves how the other lived, worked and thought. From the knowledge so gained, there came an attitude of frank good will and friendliness on the part of both.

The following winter a number of other engineering schools undertook a similar work with similar success. Under the leadership of the industrial and student departments of the Y.M.C.A., it has spread rapidly throughout the country until now, only seven years later, more than 3000 students are engaged in it and are coming into contact with about 50,000 workmen.

In a general way the activities of the student are: (*a*) reading and investigation of the general principles involved; and (*b*) a personal contact with workmen in some line of service. The latter takes many forms, but chiefly that of teaching. In all industrial centers there is a large number of men whose greatest need is English. Without it they cannot get a job alone, buy their own supplies, understand instructions for their work or even for their own personal safety; hence the padrone and labor contractor. With a knowledge of English, an opportunity of becoming industrially independent is opened up to them. Other subjects, of course, are taught, such as first aid to the injured, elementary mathematics, drawing, and civics; but English is the greatest need.

The service is not, however, confined to instruction nor to foreigners. Any sound basis of contact is utilized. Wherever possible, the classes or groups are kept small, not over five or six men to a teacher, in order to insure the element of personal contact. The work is done independently of the college curriculum, on a voluntary basis, and without pay, as this basis is by far the best in its effect on the student. In some cases the faculty has coöperated by taking over that portion of the program relating to speakers and has arranged a course of industrial lectures for all upper classmen. This has been done recently at the Sheffield Scientific School with good success. The advantages of industrial service work are felt by the employer, the workman, the student, and the community.

Employers, some of whom were at first critical, welcome it for its direct benefit and support it by giving access to the workmen, by furnishing places for teaching and in many cases paying the small necessary expenses. They see, too, its effect on the student. An employer recently said: "Two college men of equal training worked in my shop last summer. One of them 'knew it all,' was despised by the men and got

Presented at the Spring Meeting, at St. Paul-Minneapolis, 1914, of The American Society of Mechanical Engineers.

fired. The other became "one of the men" and learned from them, and nearly every evening some of the working men went to his room and he helped them in mathematics, mechanics, plain reading, etc. That fellow has a big job awaiting for him because he has learned how to handle men to his advantage."

Some of the advantages to the workmen have been pointed out above. He is given nothing which pauperizes him or lowers his self-respect. Usually he is suspicious at first of the student as a representative of the capitalistic class. He finds, however, by a contact which he has in almost no other way, that at least these boys are clean-cut, fair-minded and friendly. Those who are familiar with the attitude of workmen know their latent feeling of contempt for the young college engineer who comes among them, possibly strong in things which they little appreciate, but weak in practical things, where they are strong. We have all seen, however, the loyalty with which old, hard-headed workmen will serve young college men who have *won their confidence* and made good with them. Their distrust gives way to a feeling of pride in their successes such as they might have for their own sons who have been given advantages they themselves have not had. This change in attitude of the workman has been clearly marked, and shows a breaking down of social antagonism—a help to all (see Fig. 1).

The gain to the student, while not obvious, is quite as great. More than half the value of an executive engineer lies in his capacity to understand and work with his men. No amount of technical proficiency can make up for the absence of it. One of the greatest weaknesses of the college-trained engineer is the unconscious attitude of assumed superiority which he sometimes has, for a time at least, after graduation. It seriously limits his usefulness and his capacity for learning. The ability to understand and to work with men is the most valuable asset he can have. This our colleges, as colleges, cannot teach, for it is based on a knowledge of human nature and there is no textbook on human nature. It can be learned only by personal contact; and genuine personal contact is possible only on a basis of mutual respect and friendliness. The students are learning much more than the possibilities and limitations of welfare work. They are acquiring a personal attitude toward fellow workmen which starts them out right.

It is possible to give here only a few expressions of how this work is held by students of the stronger type. One says: "It's a wonderful, and sometimes a humiliating revelation to a fellow to get up against some of these foreign men. It just makes a fellow readjust a good deal of his previous thinking." Another, one of the best known college athletes of the day said a few months after graduation: "Remembering what I learned in this movement at Yale, when I became foreman I treated my gang of Italians as men and not as dogs, and it was really pitiful to see the way they returned the little kindnesses I showed them. Each day I was met with cheery words of greeting. When the job was complete, the men came to me in a bunch, thanked me for the fair way I had treated them and said they would like to work for me always." Another, a football captain, said a short time ago: "This industrial work is the livest thing that's struck college since I've been here. It's a real job and it's practical. Everyone of us who goes into it is bound to acquire an experience in dealing with men which the curriculum cannot give, and we need it."

Last year one graduate, who went into the office of a bituminous coal mine, gathered together a class of seven men to prepare them for examinations as fire bosses and underground foremen (see Fig. 3). With this instruction the men passed the examinations and their potential earning capacity per year was increased an average of $266.40 per man. As a result, this year 40 men applied for similar instruction and as this was beyond his capacity, arrangements were made for paid night instruction in one of the public school buildings which has been carried on by others under his supervision. Without multiplying instances we find results like this wherever men go who have had this industrial service training.

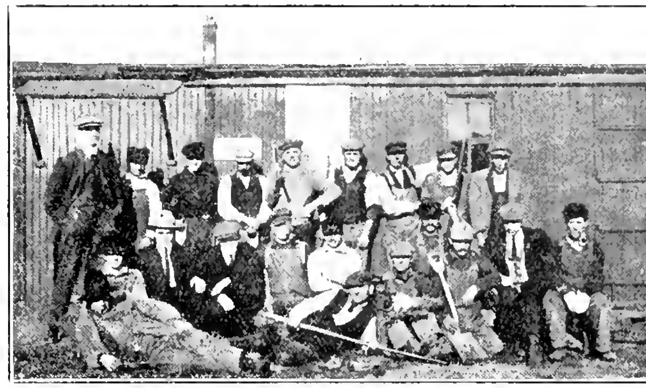

FIG. 1 INDUSTRIAL SERVICE AT WORK
Teaching English at a Construction Camp. The Lesson is Posted on the Side of the Car. The Breaking Down of Class Feeling is Clearly Present

The advantage to the community needs but little emphasis. When one considers the type of Americanism with which the immigrant first comes into contact, it is no wonder that his social standards remain low. The only Americans, whom many a Pole or Italian meets, are the saloon keeper, the ward heeler, and the grafter. Contact with clean-cut, wholesome, educated college boys opens up to him a type of Americanism which he sees in no other way. It raises his standards and kindles his ambition. The men come to the students with all sorts of questions which indicate a hunger for information and improvement.

As the industrial service movement has developed it is quite distinct from ordinary social welfare work. It

has two clearly defined objectives. The first one is immediate benefit to the laborer whom the student may be teaching; the second, less obvious, but main purpose, is the subjective effect upon the student himself, the developing of an attitude of mind, and a knowledge of the social aspects, the responsibilities, and the opportunities of his engineering profession. While the latter should not be over emphasized to the student it is never lost sight of by those directing his activities.

Such briefly is the development and nature of industrial service work. In appraising its value it is well to look at it broadly. The work which these students are doing is part of a general trend, of a changing of social standards; and of a development away from the

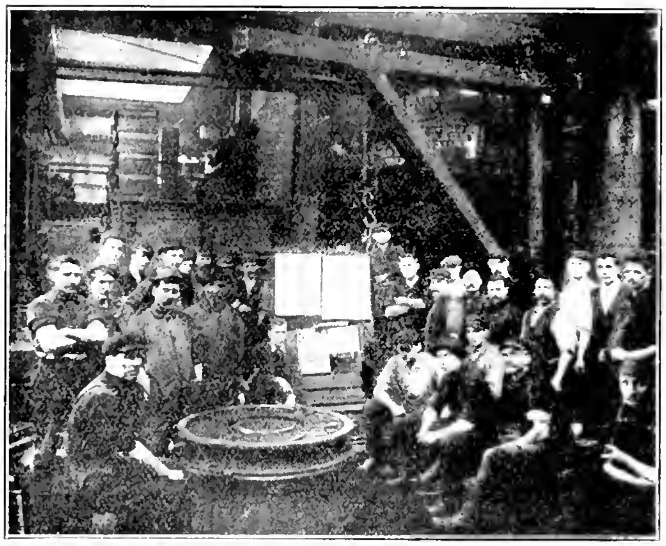

Fig. 2 Another Phase
A Noon-Day Class in a Foundry in First Aid to the Injured
Practically all of these Men are English-Speaking

industrial individualism of a hundred years or even fifty years ago. The probability is that this tendency will increase rather than diminish during the coming generation.

Industrial history shows nothing more clearly than the fact that while tools of production make high social development and physical welfare possible, they by no means insure them. The series of inventions of Hargreaves, Arkwright, Eli Whitney, Watt, and other great inventors from 1760 to 1800 resulted in a tremendous readjustment of social conditions. In England, where this change was felt first and most severely, tens of thousands of artisans found their handicrafts supplanted. They drifted into the new industrial centers and found work as best they could. The resulting conditions are a matter of history. The industrial leaders had little or no sense of responsibility for conditions of labor and living which would not be tolerated to-day. Operatives were crowded together under unsanitary and dangerous conditions, working hours were long, and wages were governed solely by the supply and demand of an overcrowded labor market. This indifference on the part of the employers was soon met by violence and industrial warfare. At length, from various reasons, conditions began to adjust themselves. Under the leadership of such men as Lord Ashley, Robert Owen, an industrial conscience came into existence, and year by year, partly through labor legislation, partly through labor unions, partly through voluntary improvement by the employers, conditions have steadily improved, and are now better than before the introduction of machinery.

The situation was never as acute in this country as it was in England, but we know that even today we have in America industries with the most highly developed machinery where child labor and dangerous or unsanitary working conditions still exist. While conditions as a whole are by no means ideal, there has come a general acceptance of the fact that reasonable hours, good light and air, safety, and a fair wage are best not only for the worker but for the employer. Men do not agree, by any means, as to just what constitutes reasonable hours and a fair wage; but none now deny the general principle.

At the beginning of this century a new force came in, the rapidly developing art of industrial management. It is still in its infancy, yet enough has been done to show that old methods of management have been wasteful and that great increases in production are possible when the right methods have been found and put into successful operation. The invention of machinery vastly increased the workman's production by giving him new and efficient tools. The new force opens up a further increase, through the higher efficiency of the workman himself and of methods of industrial management. The effect in both cases is the same. The advent of machinery produced a profound social readjustment accompanied by widespread distress and friction. The readjustments due to the application of improved methods of management will not in all probability be as great, certainly not as drastic. Standards are far higher today than when machinery was first introduced a hundred years ago and workmen now have means of defence. Moreover, the social changes possible are probably not as radical or far reaching as in the earlier development.

The development and application of the highest types of industrial management, however, is going to be difficult and delicate work, if the results are to be made a permanent benefit to society as a whole. Those who personally direct this development will largely determine the efficiency with which "efficiency" itself is applied. If the attempt is made by those in charge to seize all the benefit of the improved methods and to crowd the advantage of the employer they will either defeat or indefinitely postpone the advance. They must be experienced men, wise, fair, thoroughly conversant with possibilities and free from sentimental idealism. This means not only a knowledge of ma-

chinery, systems, and time study, *but of human nature and the rights and real needs of industrial workers.*

The executive engineer will be at the focus of this situation. He alone is in direct personal contact with the two great elements involved, capital and labor. His thorough understanding of both of these forces will prove one of the greatest elements in progress. If the man in actual charge has little knowledge of, or sympathy with, the workman, serious missteps are certain. If on the other hand to a thorough technical training and knowledge of the resources and responsibilities of the employer, he adds an attitude of fairness and friendliness, and a personal understanding of the workman involved, the new force will work out to the good of all concerned. Scientific management offers an opportunity to pay better wages, but it will require strength and wisdom to apportion the economic gain fairly, and to maintain a just distribution of it.

Welfare work in various forms has been going on for many years, ranging all the way from improvement in the small details of working conditions to the planning and building of whole model cities. Some of these enterprises, conceived in a spirit of genuine good will, have met with no response from the workmen and in spite of the great sums of money and much thought spent on them, have ended in bitterness and disappointment. In other cases welfare work has been developed quietly and wisely, each move being tested out as it was tried and has deeply influenced the lives and social standards of the whole community. In the record of these enterprises there is a glaring discrepancy of success and failure. Most of the failures have gone onto the rocks from violation of the fundamental principles of human nature. About some there has been a fine flavor of condescension; others have been made an advertisement; others have been imposed upon workmen by authority. A workman, no matter how crude his social standards, has a right to his own personality and sooner or later he will assert it. As one of their leaders put it to the writer: "Some of these employers roll their good intentions into a big bolus and jam it down the workmen's throats saying 'Here, take that; it's good for you.'" No welfare work will ever be effective unless it is preceded by a square deal, is wrought out gradually and patiently, and is the product of mutual confidence, experience and good sense.

While thousands have been invested in welfare enterprises, we know that the purpose behind them is being accomplished in scores of industrial organizations, without any special equipment, by the personal influence of some man or men in charge. These men seem to have a genius for understanding and developing the best in those under them. They have no fixed rule or system. It is a question of attitude and personality. They create an atmosphere of confidence instead of suspicion and distrust. Their influence permeates a whole factory, kindling ambition and developing better workmen and better industrial conditions. Such men can accomplish wonders without any welfare equipment. Given a welfare equipment they make it successful and beneficial to all. Their value to the employer, to the workman, and to the community can hardly be overestimated; the new art of management under the direction of such men will prove a permanent success. The development of just such men as these is the aim of the industrial service movement.

We have tried to sketch briefly the spirit of this movement, its main activities, and its relation to the general industrial situation. It seems sound. There are at present about 30,000 students in the engineering courses of the various schools and colleges throughout the United States. Of these, perhaps 5000 to 7000 graduate each year. About 20 to 25 per cent of the students become sufficiently interested in this work to get the benefits of it. What will it mean to the employer and workman in the next generation to have coming into the management of industrial enterprises 1000 or 2000 men a year, who inspire good will and confidence and have the right point of view from the start?

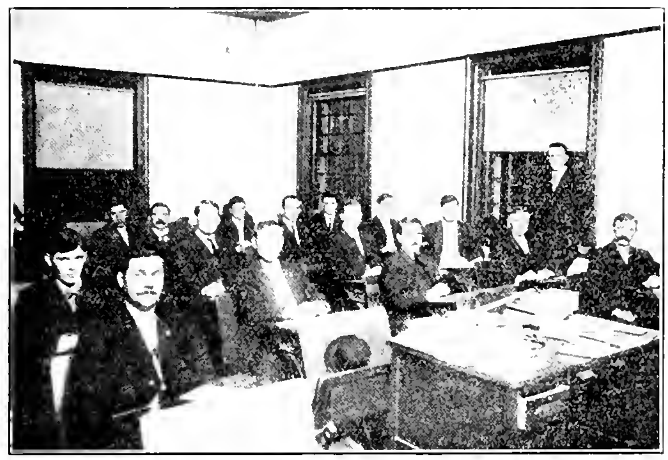

Fig. 3 A Result of Industrial Service Training
An Evening Class in Practical Mining. The Teacher in Charge is a Young Assistant Superintendent who Became Interested in Industrial Work while at Yale

So far the industrial service work has been guided by experts from the industrial and student departments of the international committee of the Y.M.C.A. These men have given it special study and have directed its activities. They have kept it free from fads, and its rapid growth is perhaps the best evidence of the wisdom with which it has been directed. Although the motive which lay behind it was a religious one, it has attracted many men who took but little interest in the ordinary forms of religious activity. Many of these have found in the progress of this work that this motive and the unselfish social one are not so far apart.

In this industrial service movement, we have a large body of students giving a reasonable portion of their time voluntarily, and outside of their regular studies, to work which is an immediate benefit to others and to themselves as coming industrial leaders. It has been suggested by members of the Society that this work might be fostered as one of the activities of the Student Branches. If so, it should be wisely and carefully directed. The experience and training which its present leaders have acquired would be available and can be called on to help organize and guide it. The work of the Student Branches is good, but they have much greater possibilities than we have yet realized. At present their main, if not sole, activity has been to arrange a series of engineering lectures, which is well as far as it goes. Some such work as this industrial service in addition would strengthen their usefulness and bring in the human element which the curriculum cannot give.

DISCUSSION

L. P. Alford. Professor Roe asked me to make one suggestion in his name in regard to the work of the Student Branches. It is that there might well be some person connected with the Secretary's office charged with the duty of visiting the Student Branches as often as necessary with this purpose. The members of this Society are employers of cadet engineers. The Student Branches are training these young engineers for full membership in the Society after they have reached the proper age and acquired the necessary experience. Through the medium of this official of the Society working with the Student Branches, it might be possible to modify and improve the training of young engineers to their advantage, to the advantage of their first employers and further to the advantage of members of this Society.

P. F. Walker. I have had the Student Section at the University of Kansas under my charge ever since 1909, when the section plan was put into effect, and I believe thoroughly in what Mr. Alford has suggested. I remember very distinctly the enthusiasm with which my boys greeted Secretary Rice two or three years ago when he came out to visit us.

With regard to Professor Roe's paper, I think the plan suggested is one that may be readily applied in the cases of sections connected with institutions located in large centers, but those of us who are in institutions located in smaller towns will have to employ different methods. One method which I believe to be workable, is based on the plan of University Extension work which Kansas, along with Wisconsin and other western universities, is developing. Vocational courses of study adapted to the needs of boys and young men engaged in the various industries of the state, are outlined. Through these, they receive instruction in the rudiments of mathematics and the sciences related to engineering, together with first principles in their application to construction work. I expect to have two or three of my seniors in mechanical engineering working as instructors in this connection next year. I mention this as a suggestion for those institutions not situated in the large manufacturing centers. The general plan brought out in the paper is a most happy suggestion, and one which may well engage the attention of the Society.

H. L. Gantt. I do not think that the membership at large has any idea of the importance of this paper. The most important problem before the industrial community today is that of the relation between the employer and employee. The reason why this is so is because the employer and employee do not understand each other.

The plan suggested to bring the employer and employee together, is the most promising step that I have seen or heard of. We see in the papers every now and then what somebody in the American Manufacturers' Association says about what the Unions are doing to them. They do not say a word about what they are doing to the Unions. That is because they do not understand each other. Foreigners who come to this country do not understand us; we do not understand them. To many of us, they are simply "Dagos" or "Hunks," to be treated as somebody in authority sees fit. Now, the activities which Professor Roe has described will bring the engineer of the future in contact with all of these people and give him a knowledge of who they are, what they are, and what they can do. I find that the Hungarian, the Pole or the Italian is very much like anybody else when you really know him.

Some time ago the following incident of interest took place. There was great dissatisfaction in a place where I was doing some work, and I investigated to see what the trouble was. My man had been there and everything was going very smoothly when he left; soon afterward, I found a good deal of trouble. On investigation, I found that the management had not carried out the promises which they had made, and their people were on the verge of a strike. My man was telegraphed for and succeeded in straightening things out as soon as the management made good their promises. Nobody had taken the trouble to find out just what the matter was. No one had talked with the workmen who, in my opinion, were absolutely right. As soon as the management began to recognize the actual conditions, the whole matter was cleared up.

Workmen are in one class and employers in another, and, as they do not know each other, they cannot, or will not, talk to each other. So long as that condition prevails, we are not going to solve our industrial problems without some connecting link. The work that Professor Roe is doing is going to turn out a lot of young engineers who will learn something about the human nature with which they have to deal and supply this link. In the ordinary college course, the student gets a lot of mathematics and engineering, all from the book end. Then he goes out on a job and sees the mechanical processes. He can learn those mechanical processes a great deal quicker than he can learn the human beings who have to operate them. You may build the best mechanism in the world, but some human being has to operate it, and if you have not a knowledge of the kind of human being who is to operate it, you are going to get into trouble.

The term scientific management is used in this paper; it means the utilization of scientific methods of investigation in the art of management. You can build up a system of management which is perfect, just as you can build a fine steam engine or automobile, but unless you have the right

personality to run it, you are just as likely to wreck it as you are to wreck the automobile or steam engine by putting an incompetent person in to handle it. Some time ago, a publisher asked me why certain books he was getting out did not sell; he had been writing papers or publishing articles on management. The reason was that he had not yet grasped the idea that a system of management is a mechanism, all parts of which work together harmoniously. He had seen a little stunt that somebody did, and had published an account of that; he had seen a stunt somebody else did, and published an account of that; he had stunts from everywhere, and his paper was filled with these stunts that had no relation whatever one to the other. They might have represented a dozen systems of management, each one a good one, but the stunts that were good in one system did not fit in the other. To illustrate what he was doing, take a picture and jigsaw it into pieces. If you have only one picture, many people can take these pieces and put them together correctly. If, however, you take six pictures and cut them up into small pieces and put them into one pile, the problem of making a complete picture from this pile is far more difficult. If you deal out these pieces indiscriminately a few at a time, the probability of making any picture complete seems hardly worth considering. Nobody would buy such pieces, no matter how much interest he had in the subject.

The flaw in the present way of trying to develop industrial management is very similar to the above. The editor cited is trying to sell pieces of systems of management not in sets, but all mixed up together. In constructing a system of management, one must first have an ideal which must be based on the knowledge of human nature as well as on a knowledge of mechanical operations and appliances. Professor Roe and his co-workers are giving their students the fundamental ideas of how to handle their workmen. It is very much better to have a man who knows how to handle the workmen using a comparatively poor system of management, than it is to have somebody who does not know how to handle the workmen with a fine system of management. The first will get along better than the second, and I want to emphasize that this training of the engineering student in a knowledge of the human nature with which he has to deal, to my mind, ranks in equal importance with strictly engineering training.

C. W. Rice. In response to the suggestion of Professor Roe that the Secretary arrange to visit the Student Branches, your Secretary tries to be up to date in every realm of activity of the members. As soon as I heard, two years ago, of this work of Professor Roe, I wrote a personal letter to every head of a mechanical engineering department in each of the schools in America where it is taught, and you would be pleased to see the magnificent responses that were received, showing that they are all alive to this movement. As a suggestion, I think that speaking for Professor Walker, as representing the Student Branches, he would be glad to have also the members of the Society visit him—men of affairs. I think there is nothing so attractive to the average student as to have a real man with a reputation, come and visit the school and give a talk.

The effect would be two-fold. You would have the interest of more members of the Society in that work and you would have more interest on the part of the Student Branches because men of affairs were interested in them. Now another suggestion has come to me with respect to students, which can be accomplished by every person in the room and by every person with whom you speak when you get home and that is, the benefit of these conventions. Every person here must be in some organization. You must have men in your employ who are just out of college or who are just starting in your organization, lacking experience. Try to co-ordinate them with the university in your town or with some organization in your town which is doing this class of work. You will have a two-fold benefit from this interest. First, your men in your employ will become more useful to you because they understand men better, and second, the men in whom they become interested will also become better employees for you.

When I first started out in 1889, I got in line at the window to take a job, and the man directly following me became a sweeper, while I commenced to file off the paper between the laminations of transformers. In the course of time, I was promoted to foreman of a room and the man who was a sweeper still continued as a sweeper. In after years I went back to that factory and found that man was still sweeping up in the yards. Now the difference was one of inspiration and of opportunity. If we interest our young men to take the time to instruct the more ordinary laborers, they become more valuable than sweepers in the course of three or four years. We must educate our men to be continuous in our employ as useful workmen, rather than continue as sweepers, and education is the only way in which you can do it. I want to urge each one of you to take the spirit of this paper of Professor Roe and apply it to your own factory now rather than to think it is something for somebody else to do in some university.

P. F. Walker. There is one other thought in connection with the Student Section and what it may mean in the life and work of the Society, that I would like to lay before you by explaining what we have done at Kansas. Each year, usually in December, we hold our annual meeting. There is no organized local section of the society membership nearer to us than St. Louis, but we are only forty miles from Kansas City where there are nearly twenty members. As many more are scattered in other cities in the state. At these annual meetings of the Student Section, we make a special point of inviting every member of the Society who is within reasonable distance, and some of them always come. I speak of this as a suggestion, indicating what the Society might do in the way of recognizing the Student Section centers as nuclei for local sections of the Society for the regions adjacent, when the location is distant from those cities where a full local section organization is practicable.

L. P. Alford. I feel impelled to say another word in the name of Professor Roe. I know that in making this suggestion he has had no thought whatever that there has been a lack of coöperation between the Secretary's office and the Student Branches. It is not that at all. He has been merely trying to point out the possibility of further and new activities and suggesting the way in which some of these can be initiated. Personally, I am most heartily in sympathy with the suggestion of Mr. Rice that some members of the Coun-

cil or other members of the Society take occasion to visit and address the Student Branches.

Professor Roe's paper does not reveal his personal connection with this great movement. He is its Father. He is the man through whose far-sightedness and initiative the work was started. He deserves a generous measure of our esteem and commendation for having inaugurated a social movement in our engineering colleges that promises to be of great benefit to engineers and industry.

H. L. Gantt. To visit these Student Branches and start this working going, will cost something. You cannot do any of these things without money. I feel that many manufacturers would be willing to put up money for the advancement of the Society. Somebody has suggested that we might have manufacturers who are contributing members or something of that kind. This suggestion is well worth considering. The possibilities of the engineer as an economic factor, have been emphasized most clearly within the last twelve hours, but we need money to make them realities. All we need now is to have some way of financing this growth which seems to have started with such a rush.

Paul Doty. I think that most employers, at least modern employers, recognize their obligations in connection with the general subject of welfare work. The thought that "a man is his brother's keeper" does seem to permeate the minds of a good many employers. We have here in St. Paul in our company work, an employees' club, formerly called The Techne Club. We have some educational work, some welfare work, we have talks on "safety first," on efficiency and we also have talks covering good management and some on bad management. We try to make these meetings of employees of vital interest to them. We bring home homely suggestions—we bring home their work-a-day life. These meetings are held as frequently as necessary, at least once a month, and in addition to the practical side of the work, the construction, the manufacture, the distribution—all the operations of the property—we have the social side, a dance occasionally, a picnic now and then and an excursion during the summer season—something that will maintain the human interest, and bring together the employer and employee.

We try to have a sense of the need of the understanding which Mr. Gantt has referred to. We know that employers without employees could accomplish very little, especially in continuous service business like public utilities when twenty-four hours a day, three hundred and sixty-five days a year, somebody is working somewhere with us, and we need something outside of the mere payment of wages as compensation to the employee. I do not go so far at the present moment as to refer to service pensions or service annuities, or profit sharing, or other form of welfare work as it is understood generally, but all those things we do have in mind.

The educational work is particularly important and is under men like Mr. Walter C. Beckjord and his associates. A few years ago, Mr. Beckjord was a student at the University of Minnesota and came to us as one of our cadet engineers. We have that feature established to bring about the training of the younger men, and through years of faithful service, he is now occupying a position of responsibility and has been President of the branch of our educational work including both the gas and the electrical departments.

We claim no special credit for the work we are trying to do. It is work that is being advocated by the National Electric Light Association. It has been recommended by Mr. Insull, President of the Commonwealth-Edison Company, who has suggested that educational work be carried on in the time of the employer, not only the time of the employee—after hours—when a man perhaps is tired and does not care to come out; but that hours be set aside from the employer's time for this educational work. That, I think, is a wonderful step forward—where a man recognizes the responsibility to employees to give time for educational work on the company's payroll. The movement is here. It is the coöperative movement and we must, as progressive men, progressive engineers, recognize that there is work for us to do along this line. We are not wholly discharging our obligations by the giving of the pay check or the pay envelope at the end of the week or the two weeks' period.

H. L. Gantt., Professor Roe does not regard this as welfare work. Welfare work, as I understand it, is something done by the employer for the employee. Now, personally, I am not a tremendous advocate of welfare work as such. Professor Roe says here: "A workman, no matter how crude his social standards, has a right to his own personality and sooner or later he will assert it. As one of their leaders put it to the writer: 'Some of these employers roll their good intentions into a big bolus and jam it down the workmen's throats saying "Here, take that: it's good for you."' " While I have no idea that Mr. Doty has any reference to welfare work of that character, yet there is a good deal of so-called welfare work that is strictly of that character, sometimes with the best intentions in the world. The work which Professor Roe is doing is not in this class and seems to me to be at the root of our industrial progress. The gap between employer and employee will widen, if we do not do anything to close it up. It is just equally important to public interests and to the interests of the employer, to those of the engineer and to those of the employee that this work be done.

James Hartness (written). I have read this paper entitled "Industrial Service Work in Engineering Schools" with keenest interest and pleasure. I am in most hearty accord with the central motive and am confident that it will have a far reaching and beneficial effect not only on the undergraduates, but on all engineers who are in receptive condition for progressive ideas.

The engineer should be in the forefront of the campaign for bringing people together—not only people of different nations, but people of different walks of life. The trend of the public's social and economic views will begin to turn upward as soon as these various peoples begin to understand each other. But so long as the workman fails to understand the business man, and the business man the worker, the trend of our ideas will be toward anarchy.

The paper should serve as a keynote for many others that will bring out the great importance of this fact, for it is the engineer, who, as the director of men, is in the position to put into practical effect many regulations that will lead to a better relation and a better understanding between man and man.

This can be truly called welfare work, but it should not carry with it the impression that it is solely for the laborer or even for the newly arrived immigrant, for it is as truly welfare work among the well-to-do.

Our success as engineers will be greater if we work along these lines and the value of the engineer to his country will be beyond measure if he realizes his obligations and opportunities along the lines stated.

Although the paper sets forth this work in its bearing on the student and the humblest workers, it will carry to every one the message that there are opportunities of this kind not only between the business man and the worker, but also between the workers of different grades when measured according to their skill and knowledge.

I congratulate the writer on presenting this subject to our Society and hope that it will be followed by others tending to offset the present unfortunate trend of class feeling in this country, for much harm and very little good will be obtained by any scheme that fails to take into consideration that each man has a heart as well as a brain, and that each man may best be directed by someone in whom he has confidence, by someone who understands him and that the physical energies of man must be directed through the man's inner self. You must get at his inner motive instead of trying to forcibly impress his body into service.

THE AUTHOR. So far from implying criticism, the suggestion referred to in the discussion sprang from the very effectiveness of Mr. Rice's relations to the Student Branches. No one knows better than the engineering instructor his interest in the Branches, or the value of his visits to engineering schools. But, as the chief executive officer of the Society, the Secretary has the responsibility for many activities, of which the Branches constitute but one. The President and Council members are men of important outside interests. None of the officers of the Society are in a position to give all, or even a large portion, of their time to the Branches, even if they would.

And yet there is a great field there. The Branches are increasing in number and membership. Their value, already demonstrated, may be greatly enlarged; and the good work done by the Society under existing conditions justifies an extension of its activity. The present officers cannot, in justice to their other responsibilities, however, be called on for a very much greater contribution of time than they are now giving.

What is suggested, therefore, is a salaried officer of the Society, who should be a college man of experience, wide acquaintance and constructive ability, who would, under Mr. Rice's direction, organize Student Branches and supervise their activities, bring the officers and active members into closer relations with engineering students, assist in arranging schedules of speakers, help students in securing wise summer employment, and inquire into and develop such new activities as this Industrial Service work, which the writer believes to be of sufficient promise to justify, of itself, the step proposed. But it is a work which is expert in nature and must be guided wisely to keep it free from fads and the mistakes of immature enthusiasm.

This program is merely a suggestion. The right man would materially extend the field as his work progressed. Like the education, with which it would be allied, it would be constructive work for the future and its influence would be most felt in the next generation.

GEAR TESTING MACHINE

By WILFRED LEWIS, PHILADELPHIA, PA

Member of the Society

The gear testing machine, shown in Fig. 1, is the result of the writer's efforts to realize in concrete form an ideal machine for the purpose of continuing the experiments reported to the Society by Prof. Guido H. Marx at the Annual Meeting in 1912. The possibility of testing heavier gears at higher speeds with comparatively little power occurred at once to Mr. Ralph E. Flanders and to the writer as pointed out in their discussions of the paper, but the problem remained to design a suitable machine which might also be used to supplement the experiments made by the Committee on Standards for Involute Gears to determine the friction losses and the running qualities of various types of gearing. After making a number of preliminary sketches, the writer was about to put them in the hands of a draftsman, when he had the good fortune to meet Prof. E. P. Lesley, one of Professor Marx's associates, who accepted the task of preparing the working drawing. The machine as it now appears is due in large measure to his careful attention and skill in the perfection of every detail and the writer is pleased to acknowledge many helpful suggestions which have broadened the scope of the undertaking and made the design a practical possibility.

The machine proposed is based essentially upon the principle of the machine used in testing by the Committee on Involute Gears, which is to put the teeth under a working load without consuming an excessive amount of power. The design, however, has been modified to facilitate changes in the working load and in the test gears employed. At the suggestion of Professor Lesley, it has also become possible, not only to change the amount of the working load while running, but also to change its direction, thus producing the effect of reversing loads upon the teeth while running continuously in the same direction.

The apparatus has a hollow shaft made in two parts, A_1 and A_2, united by a clamp A_3, also made in two parts to facilitate assembling. At one end of this hollow shaft is a flange to receive the steel gear ring G, which serves as a permanent part of the apparatus and is strong enough to resist the stresses due to testing.

Besides the hollow shaft A, there are two solid shafts C and S on which are mounted the gears or pinions to be tested. Shaft S passes through hollow shaft A and has a flange, at one end of which is mounted test gear T. Shaft C, parallel with shafts A and S, carries the wide-faced pinion P, which is in mesh with both the permanent gear ring G and test gear T.

Shafts A and S are connected at their opposite ends by a novel device through which any desired amount of

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load in either direction can be applied to the teeth, whether at rest or while running in either direction. To accomplish this purpose, the hollow shaft A is flanged to receive the pneumatic cylinder M, in which is the piston N, firmly secured to the shaft S. Pins D D are driven into the piston N through the openings in the cylinder M and upon the projecting ends of these pins rollers R R are mounted upon roller bearings. A bolt passing through the pins, piston and shaft secures the whole in place. These rollers R R engage helical segments H H let into the walls of the cylinder M. Air pressure can be applied to the piston N on or if preferred, a motor drive may be used in connection with the extended end. When the gear wheel T is to be tested, the intention is to use it in connection with a steel pinion; and when the pinion P is to be tested, the intention is to make it of cast iron and cut down the width of the teeth engaging with T, by nicking down on either side to a smaller width of face.

When a tooth breaks in the wheel T, or in the pinion P, it is important to avoid the complete destruction of the apparatus by the jamming of the remaining teeth on their ends, to maintain the wheels G and T in proper relation to each other, and for this reason, the stops

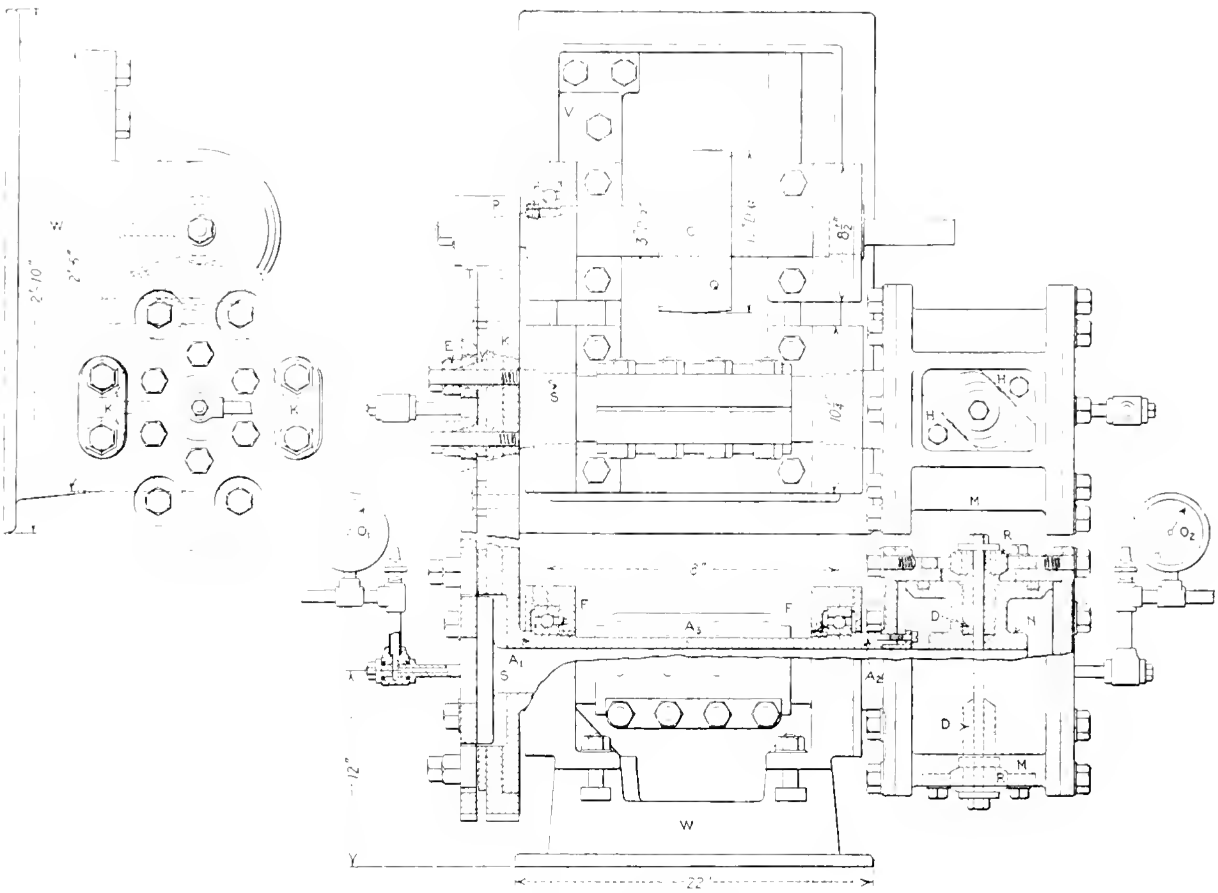

Fig. 1 Gear Testing Machine

either side to give a slight amount of end motion to the shaft S and so, through the action of the rollers upon the helical segments, a slight angular motion is produced between shafts A and S, resulting in a pressure between the teeth of the gears upon these shafts and the teeth of the pinion on shaft C. Pressure gages O_1 O_2 connecting with each side of the piston area are calibrated to record the resulting pressure on the gear teeth, taking account of the piston areas, the pitch of the helical cams H and the diameter of the gear wheels.

Since but little power is required to drive the apparatus, the pinion P is simply clamped to the shaft C, by a nut on its tapered end. The shaft itself is made heavy for the sake of stiffness and a pulley O, between bearings, is attached for driving from a countershaft, K K, with their adjustable eccentrics E E, are employed. The block K is clamped to the wheel G through the intervening eccentric bushings E E. The intention is to keep one of the clamping bolts tight while the other is loosened and the eccentric adjusted to a predetermined amount of clearance on either side, after which both eccentrics are to be clamped. These stops do not come into action unless a tooth is broken or deformed. Then they cause both gears, G and T, to run together. By means of these stops it is also possible to study the effect of a predetermined irregularity in forming or spacing the teeth. For instance, an abnormally wide space or tooth can be simulated, when broken out or purposely cut away, by the position of the stops and the pounding effect in running will be

evident as the result of a certain measured irregularity.

The shafts A and C are mounted in ball bearings to reduce friction and as a matter of expediency the scale of the apparatus has been determined by the bearings F F on the shaft A. These are of the largest commercial size and to make them available the shaft A was cut in two and united by the clamp A_3. The bearings for the hollow shaft are firmly bolted and doweled to a bed plate W, while those for the pinion shaft are adjustable to the diameter of the pinion used, a distance piece V of proper width being used in every case to prevent movement under load.

It will be seen that the apparatus is capable of determining to a nice degree of accuracy a number of unsettled problems of great practical importance at a very small expenditure for wear and tear and power. Jigs will be made for drilling the gears G and T after cutting the teeth, so that the relative positions of the two wheels may be accurately fixed. Friction is practically eliminated in the ball and roller bearings, and what remains must become inappreciable under the well-known influence of vibration when running, except that due to air resistance and the friction in the teeth. With some accurate means for measuring the power consumed, both of these variables can be determined better than ever before. The apparatus in skilful hands should therefore solve the mooted question of the effect of speed on strength, and questions of durability, wear and noise can be studied at a small outlay in power and materials. It is possible that some slight modifications may finally be embodied to facilitate construction, but the machine so shown is believed to contain the elements needed for an exhaustive examination of the subject of gearing in all its phases and the writer hopes it will appeal to some one interested, who has the means to build it and time to experiment on the lines so well indicated by Professor Marx.

DISCUSSION

Elmer H. Neff: As I understand it this paper is simply a record of a design which has never been built. It would appear therefore that the real discussion of this machine will be brought out when it has been built and an attempt made to draw conclusions from experiments made with the machine. At that time more details will be apparent than a hasty examination reveals. We will be able to judge somewhat of the statement in the last paragraph suggesting that vibration reduces the quantity of helical friction loss in the machine to a negligible quantity, leaving only the friction of the gears as they exist.

Henry Hess: Mr. Lewis has done a really extraordinary amount of self-sacrificing work in this line, for which he has earned chiefly criticism, largely interested criticism, but criticism nevertheless. There is probably no other one man who has given so much time and effort with absolutely no incentive of a financial reward of any kind and with no interest except a purely engineering one. It would be a very good thing if it were possible for the Society to make available surplus funds, which it has not at present, but which it may hope to have some day, for the prosecution of experiments with a machine such as this of Mr. Lewis' design. I do not mean to say necessarily this particular machine, but any machine which will realize the object underlying its design. I move that the Society suggest to the Council the initiation of steps to render possible the carrying out of experiments of this character.

P. F. Walker: It may be of interest to some to know that in the engineering laboratory at the University of Kansas we have under way tests to determine the friction loss in gears. Our plans cover more than the gears, however, our first work having been on the universal joint as made for automobile transmission. On this latter portion of our work I had thought to comment to-day, since it will be some months before our work on the gears will be brought to a point where any report may be made.

The point of greatest difficulty in the measurement of friction losses is in the measurement of power. Where the power transmitted is in fairly large amount and the friction loss small, and the power input and power output are measured in their full amounts, the small difference indicating friction loss is bound to absorb all errors. The error may be a small percentage of the power transmitted and still be so large in proportion to the loss being determined as to render results worthless.

For this reason, in the universal joint work we adopted the "Load-back" method of testing. This consists in operating the joint between two electrical machines, the shafts being connected through the joint, one machine acting as motor and the other as generator while the first uses the current generated in the second. The only power supplied from outside is that required to make up the losses of machines and joint combined. The machine losses must, it is manifest, be determined separately, but a distinct advantage gained is the elimination of the large power readings. In any form of test the machine losses must be determined, thus introducing that detail in the work irrespective of other determinations.

We have spent three years on the universal joints and have gotten to the point where we are about ready to make the report. On the gears, only the preliminary runs have been made, but I have reason to believe that this work will progress much faster than the other.

A. G. Christie: It may be of interest to know that a number of the large state institutions in the West have engineering experiment stations in connection with the University. Illinois, Wisconsin and Iowa, all have experimental stations in connection with their state University. These experimental stations are not tremendously wealthy, but they do have each year certain sums of money set aside for investigation work, and I believe that a great deal could be gained both by the stations and by the Society, if the Society would coöperate with these engineering experiment stations in carrying on research work. While I was at the University of Wisconsin we would have welcomed such coöperation very greatly. In fact we did carry out some work suggested by the ventilating engineers. I believe the universities would welcome any suggestions coming from the Society.

The Author: It is true, as Mr. Neff has stated, that the

gear testing machine described in my paper has never been built. It is simply a design intended to meet the need of further light upon a number of questions pertaining to the use of gears. As suggested by Prof. Walker, there are other ways of measuring the friction losses in gearing, and if good results can be obtained by electrical methods, it will be interesting to have such experiments for comparison.

There are, however, other features of this testing machine which do not appear to be so easily superseded by a motor driven generator, and it is difficult to imagine how the load on the teeth can be varied and reversed with the same facility and measured with the same precision. Nor does it appear how the effects of irregularities in forming and spacing the teeth can be so carefully studied under different speeds and loads. Perhaps the same problems can be solved to advantage in other ways, and different methods of attack are certainly to be desired, but the direct mechanical method appeals to me as the most accurate and reliable. Friction can be practically eliminated by ball and roller bearings and if the little that remains is not further reduced to a negligible quantity by vibration, it is reassuring to know that the conclusions will not be seriously affected thereby. Vibration of a pattern on a molding machine certainly does eliminate most of the friction between that pattern and the sand, and it is well known that bolts and nuts work loose in machinery subject to vibration, unless special precautions are taken to secure them.

If the interest in the subject warrants the construction of a machine, as implied in the motion of Mr. Hess, by all means let us have the type of machine subjected to the fullest and freest discussion. I have simply presented a design which appears to me to be complete and satisfactory, and I shall be glad to welcome other ways and means upon their merits.

A FLOW METERING APPARATUS

BY A. M. LEVIN, CHICAGO, ILL.

Member of the Society

The pitot tube and venturi meter, while fully reliable, with proper handling, for determining the flow in closed channels, are apt to give more or less doubtful results in less experienced hands. An apparatus less sensitive to errors and, in a majority of cases, quite easy to install, is the elbow or bend meter described in this paper. The principle on which the measurement of flow in this apparatus is based, is that when the velocity of a fluid, as a whole or in part, is changed, a change in pressure accompanies the change in velocity, and hence, when the areas carrying the fluid before and after the change are known, the original and final velocities of the fluid can be determined from the change in the pressure that has been noted. The apparatus (Fig. 1) consists simply of an elbow or bend provided with suitable pressure ports in the inner and outer curved walls, by means of which the centrifugal action set up in deflecting the course of the passing fluid is communicated to the registering apparatus.

FORMULAE RELATING TO THE FLOW BEND

If it be assumed that, when passing through the bend, the velocity in each stream line is proportional to the distance from the center of curvature, so that all particles of the fluid in the plane normal to the neutral axis move together, then the centrifugal action normal to the axis will be as illustrated in Fig. 2.

Here m is an elementary mass of the fluid, of a sectional area a normal to the diameter DD and of a length dx. In turning the bend, the centrifugal force C, acting on m will cause the pressure acting radially in front of it to be increased the amount dp, and the increase in pressure on the area a must at all instants balance the force C. Hence, we have

$$adp = C = mxw^2$$

and since

$$m = \frac{\delta}{g} adx$$

we get

$$\frac{dp}{\delta} = \frac{w^2}{g} xdx$$

With respect to the density δ in the above equation, the following assumptions may be made:

I That δ remains unchanged during the flow, as in the case of water

II That δ changes at the rate an isothermal compression or expansion would call for

III That it changes at the rate an adiabatic compression or expansion would call for

Case I. δ is constant. Through integration of the general equation

$$\frac{1}{\delta}\int_{p=p_1}^{p=p_2} dp = \frac{w^2}{g}\int_{x=r}^{x=R} xdx$$

after certain substitutions, with V_m as the mean linear velocity, there will be obtained

$$\frac{V_m^2}{2g} = \frac{R+r}{4(R-r)}(h_2 - h_1)$$

Finally call $R - r = D =$ the diameter, or width of the channel and $\rho = \frac{R+r}{2} =$ mean radius of the bend, then we get

$$\frac{V_m^2}{2g} = \frac{\rho}{2D}(h_2 - h_1)$$

which may be written

Abstract of paper presented at the Spring Meeting, at St. Paul-Minneapolis, 1914, of The American Society of Mechanical Engineers.

$$V_m = \sqrt{\frac{\rho}{2D}}\sqrt{2gH}$$

where H is the difference in the pressure at the outer and inner wall of the bend, in feet head of the fluid.

The corresponding formula for the pitot tube is

$$v = \sqrt{2gH}$$

Hence, the velocity measured by the bend will be $\sqrt{\frac{\rho}{2D}}$ of the velocity measured by the pitot tube for equal differential pressure. In other words, the differential pressure in the manometer tube will for the same velocity of the fluid be $\frac{2D}{\rho}$ of the pressure indicated by the pitot tube.

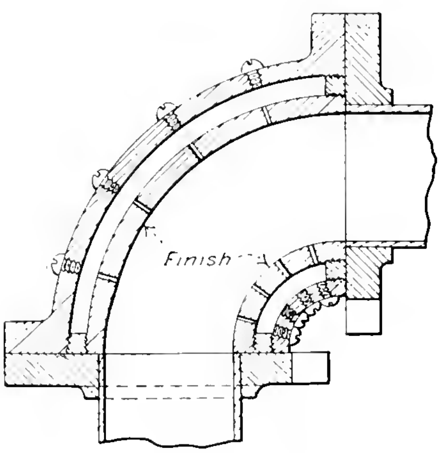

FIG. 1 METERING BEND

Case II. δ changes as by isothermal compression. Hence

$$\delta = \frac{P}{P_1}\delta_1$$

which substituted in the general equation gives

$$\frac{P_1}{\delta}\int_{p=p_1}^{p=p_2}\frac{dp}{p} = \frac{w^2}{g}\int_{x=r}^{x=R} x\,dx$$

and through integration and reduction

$$V_m = \sqrt{\frac{\rho}{2D}}\sqrt{2g.144\frac{p_1}{\delta_1}\log_e\frac{p_2}{p_1}}$$

Case III. δ changes as by adiabatic compression. Accordingly,

$$\delta = \left(\frac{P}{P_1}\right)^{\frac{1}{n}}\delta_1$$

which substituted in the general equation gives through integration and reduction, as previously

$$V_m = \sqrt{\frac{\rho}{2D}}\sqrt{2g.144\frac{p_1}{\delta_1}\cdot\frac{n}{n-1}\left[\left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}} - 1\right]}$$

Hence, the general formulae for the bend are practically those of the pitot tube covering corresponding cases, with only the factor $\sqrt{\frac{\rho}{D2}}$ added, so that, strictly speaking, the use of the bend does not introduce any really new formulae.

In order to determine what results could be obtained by the use of the flow bend, investigations were made with a special apparatus designed for this purpose, steam being used as the fluid under test. In Fig. 3 are plotted the weight of steam per minute on a base-line which is the product of height of water-column, in inches, by the corrected density of the steam.

The bend was of a sectional area of 1.24 sq. in., and was attached in a $1\frac{1}{2}$-in. steam line, with one throttling valve in front and one behind it, whereby the pressure and the velocity of the flowing steam could be regulated at will. At the time of planning for the apparatus it was hardly expected that the abrupt change in area, from a cylindrical tube 1.6 in. in diameter to a square tube $1\frac{1}{8}$ in. on a side would be productive of the very best results. However, it was reasoned that as the centrifugal force is more or less independent of whirls in the body of the fluid, any irregularities in the flow would not have as great an

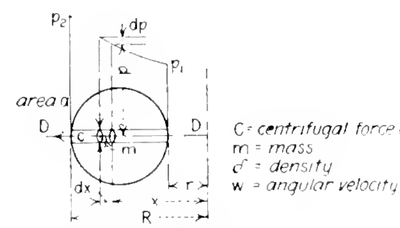

FIG. 2 DIAGRAM OF MOTION OF A PARTICLE OF FLUID IN THE FLOW BEND

influence on the results as it would in the case of the pitot tube or in the venturi meter. It was also assumed that the great number of pressure ports lengthwise of the bend would have a tendency to average up the possibly varying pressures throughout its length. Besides, it was in part the object of the investigation to determine if violent irregularities in the flow really would have any great influence on the readings; because on that circumstance would depend, largely, the final usefulness of the apparatus, as compared with that of those in general use.

From the pitot tube formula, the corresponding formula for the bend may be obtained, as explained, by adjoining the factor $\sqrt{\frac{\rho}{2D}}$. Thus, for the present case

$$W_m = 7.62\,a\sqrt{\frac{\rho}{2D}}\sqrt{h_w\delta}$$

where W_m is the weight in lb. per minute, and h_w head in inches of water. The average area through the bend was 1.24 sq. in.; the factor $\frac{\rho}{2D} = \frac{2}{3}$, or $\sqrt{\frac{\rho}{2D}} =$ 0.8165. Hence, for the bend used we have

$$W_m = 7.62 \times 1.24 \times 0.8165\sqrt{h_w\delta} = 7.716\sqrt{h_w\delta}$$

This formula is represented by the full-drawn curve of Fig. 3.

The approximate velocity formula, which applies quite closely for steam of the moderate velocities of the present tests, may be written from formula for the pitot tube, as

$$v_s = 0.8165 \times 18.29\sqrt{\frac{h_w}{\delta}} = 14.93\sqrt{\frac{h_w}{\delta}}$$

The curve representing this formula (the parabola) is shown in Fig. 4, and underneath are plotted, in feet

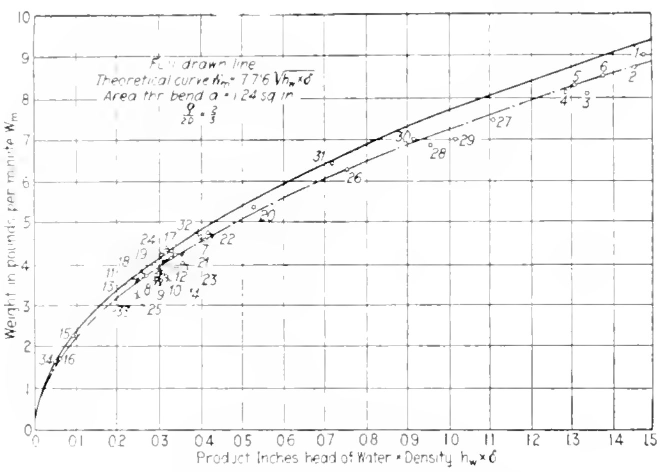

FIG. 3 CURVES OF WEIGHT PER MINUTE

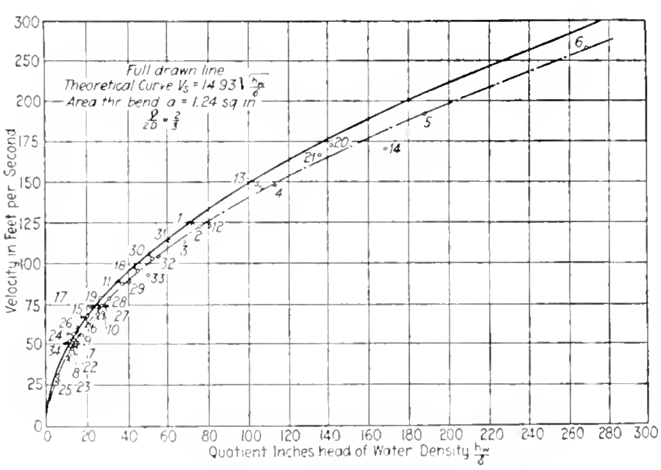

FIG. 4 VELOCITY CURVES

per second, the velocities obtained in the 34 tests. The average velocity curve to suit the plotted points would be approximately as shown in the broken line, and it will be seen that the majority of the plotted points come as closely to their proper places as could reasonably be expected. It may be said that on the whole and under the circumstances, the results come surprisingly close to what the theory would have predicted; and it is judged that with reasonable care to eliminate as much as possible all disturbing influences with respect to the flow through it, the bend will in accuracy measure up well with the instruments in general use.

DISCUSSION

S. M. WOODWARD. This is an interesting matter and the instrument as explained seems to have given good practical results, but I doubt whether the correct theory of flow around the bend is as simple as the mathematics given in the paper would indicate. One of the fundamental assumptions made, is that in a fluid flowing around the bend, all the particles have the same angular velocity. It seems to me that it would be more rational to assume the same linear velocity. This would not affect the practical use of the apparatus but it would somewhat affect the calibration.

Flow around bends is a complicated matter. As motion around the bend begins and the pressure becomes less on the inner boundary of the curve, this change of pressure is accompanied by a corresponding change in velocity distribution through the cross section. At first, the diminution of pressure produces an increase of velocity on the inner side of the bend, which is the opposite of the condition assumed in the paper.

THE AUTHOR. I readily agree with Professor Woodward that the theory for flow through bends is, in its entirety, quite complicated; but in so far as it pertains simply to the centrifugal force coming into play it does not seem, necessarily, involved at all. The matter to which Mr. Woodward refers, I should perhaps have stated more fully, in order to be more readily understood.

The force acting on a given section of the fluid, and causing it to deviate its course is, successively, changing in direction as the fluid proceeds through the bend, but it always passes through the center of curvature of the bend. Its effect, therefore, upon the fluid, at any time throughout the sweep of the bend, will be a certain force through the center of curvature, the centrifugal force, and a couple, which latter causes a whirl or eddy. But as far as the centrifugal force is concerned the whirl is of no consequence whatever.

With this in view, the assumption with regard to the stream lines of Fig. 3 would, of course, better be looked upon as referring to particles of the fluid of certain defined density, rather than strictly to some mathematically defined material points. However, any way this may be looked upon, under the conditions of the problem the assumption seems justified, and that it really is so the results verify.

With regard to the elementary section through the fluid, Fig. 2, which is the basis for the deduction of the formulas, there is no necessity for considering it as being composed of the identically same material points for every section of the bend. That various particles may replace each other from section to section does not affect the reasoning, so long as they change position in a manner that will not affect the centrifugal force.

The substance of the proposition may, perhaps, be stated simply thus: There is a certain mass passing through the bend, the center of gravity of which is located, and of known velocity; there is then, in order to find the value of the centrifugal force, no need for knowing whether the mass revolves, or how it acts, so long as its center of gravity follows a defined path.

Mr. Woodward's statement that the velocity of the fluid increases on the inner boundary of the bend as the pressure decreases, I can explain only on the ground that he refers to the velocity in the whirl. I have by "velocity" considered only that which causes the fluid to progress through the bend.

RAILROAD TRACK SCALE

BY W. WALLACE BOYD, BALTIMORE, MD.

Junior Member of the Society

The immense freight traffic of the railroads, with the necessity of interchanging cars in order that the merchandise which they contain may reach its destination without transfer, demands an accurate method of determining the weight of the loaded car as it stands upon the rails.

In order properly to weigh these loads, track scales of sufficient capacity and length must be supplied at the necessary points along the route; and above all, these scales must be of such construction as to put their continued accuracy beyond a doubt.

In these scales the following essential conditions must be observed:

a The foundations must be massive enough to resist successfully distortion or displacement due to repeated applications of the load.

b Connections should be strong enough to resist the load imposed upon them even after considerable corrosion has occurred.

c Unnecessary friction must be eliminated since it produces sluggishness of action, insensitiveness to the smaller loads and inaccuracy in indicating the load.

d There must be a proper distribution of the metal in the levers to avoid undue deflection which may cause either quickness or slowness of action; or may cause inaccuracy through change in the length of the lever arms.

e All knife edges should be in the same plane and each a true edge, hard and sharp; if the edges are not in the same plane, the bearings have a tendency to slide, producing a pressure against the lever on the low side of the knife edge, causing friction and sluggishness of action.

f There must be provision for draining the pit thoroughly and keeping it dry, to prevent corrosion as much as possible, as well as for inspection. Knife edges are subject to corrosion and this drainage and inspection must be provided in order to insure the continued accuracy of the scale.

In the design of a scale the maximum load per truck must be considered, otherwise the levers and connections will be too light and mischievous deflection with possible failure occur. At the present time the largest axle used in freight service has the 6-in. by 11-in. journal with a capacity of 50,000 lb., or a maximum load of 100,000 lb. upon one truck (four wheels).

Assuming a scale of four sections, of 150 tons total capacity, the usual allowance would be for a load of 37.5 tons at each section, plus a certain additional load due to the weight of the bridge and its dead load. On this basis, however, the levers and their connections would be too light, since with a load of 50 tons per truck moving across the platform, it is very evident that the stresses would mount higher than those for which allowance was made. By taking into consideration this maximum axle load, it is possible to have the main levers of all track scales made standard and with this standardization they become interchangeable and ready for immediate use.

The bridge may be built in one piece, or made in sections having a flexible connection, according to the length of the platform. For scales of large capacity,

THE ARROWS INDICATE THE DIRECTION OF THE LOAD
A—MAIN LEVER
B—END EXTENSION LEVER
C—MIDDLE EXTENSION LEVER
D—FIFTH LEVER
E—SHELF LEVER
F—BEAM

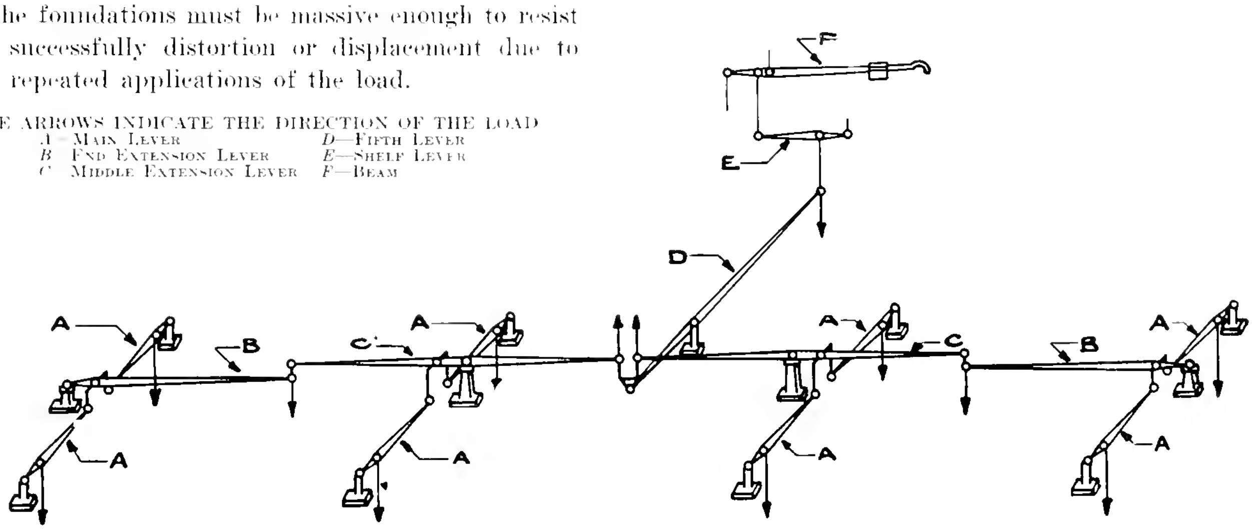

FIG. 1 LEVER DIAGRAM

Presented at the Spring Meeting, at St. Paul-Minneapolis, 1914, of The American Society of Mechanical Engineers.

and considerable platform length, it is advisable to design a bridge for the largest possible load that may come upon it, making it in sections, the joints of which come over the main bearings. This obviates the objectionable pounding upon the knife edges, which occurs with a continuous beam, due to deflection, and there are other advantages, such as ease of handling, etc.

To relieve the knife edges of some of the hammering, which they are sure to get when the moving wheels roll from the solidly laid track to the live rails on the weigh bridge, it is customary to carry the bridge girders somewhat beyond the end of the platform. The most satisfactory plan would be to prolong the girders for the end span so that the load would be applied at their middle points. This, however, would have the objection that the pit and the bridge would be too long, entailing unnecessary expense. On examining several

At fifth lever	25
At shelf lever	200
At butt of beam	1000

The lever lengths in Fig. 2 are expressed in terms of the short arms, x, of the levers, designated as "fulcrum" lengths. One-half the platform length, which is considered in connection with the levers shown, is 25 ft. = 300 in.

The length from the transverse center line of the scale to the load knife edge on the end extension lever is $24x + 5$ in. and the weigh bridge girder extension is one-fourth of the end span, or $\frac{11}{3}x$. Then

$$300 \text{ in.} + 3\tfrac{2}{3}x = 24x + 5 \text{ in.}$$

$$x = 14\tfrac{5}{8} \text{ in. (approximately)}$$

which gives for the extension of the weigh bridge girders beyond the end of the platform

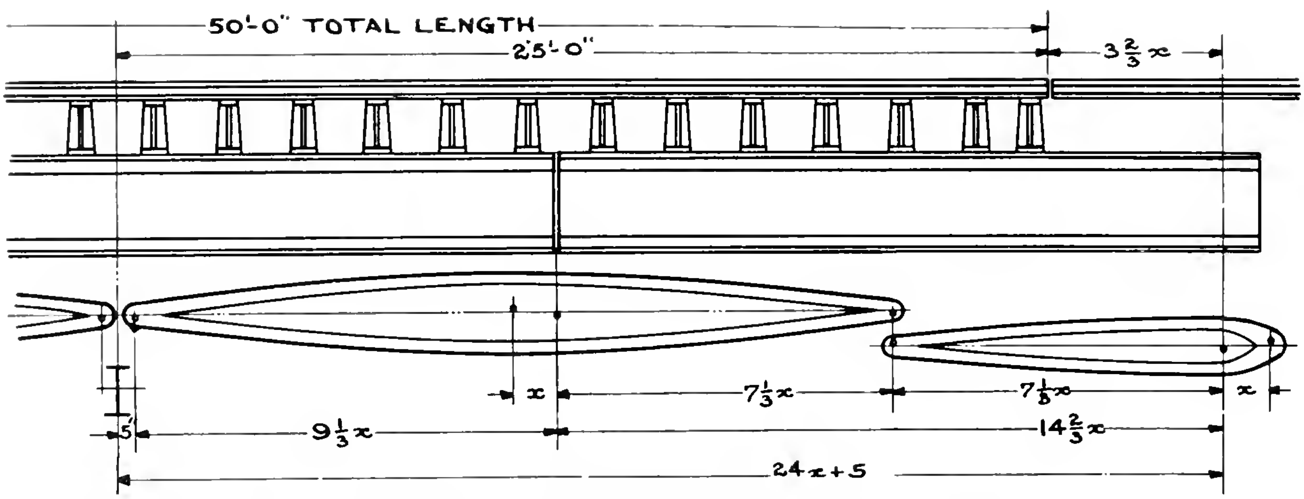

Fig. 2 Diagram Showing Dimensions of Platform, Girders and Levers

designs, no standard proportions were observed, the length of the extension varying from less than a fourth the length of the end span down to nothing.

PROPORTIONS OF LEVERS

In Fig. 1 is shown a lever diagram and in Fig. 2 the platform arrangement and the proportions of the middle and end extension levers for a track scale. In this design it is assumed that the extension of the weigh bridge girders is $\frac{1}{4}$ of the length of the end spans.

Allowing 5 in. on each side of the transverse center line for the connections of the middle extension levers to the fifth lever, the necessary lengths of the weigh bridge girders, and the lengths of the end and middle extension levers may be found as follows, assuming the leverage ratios to be:

Main levers	3
Extension levers	$8\frac{1}{3}$
Fifth lever	8
Shelf lever	5

This makes the leverage ratios at the several connection points as follows:

$$\frac{11}{3} \times \frac{117}{8} = 53\tfrac{5}{8} \text{ in., or 4 ft. } 5\tfrac{5}{8} \text{ in.}$$

The lengths of the levers will be

End extension, fulcrum $14\frac{5}{8}$ in., total length **10 ft. $1\frac{7}{8}$ in.**

Middle extension, fulcrum $14\frac{5}{8}$ in., total length 20 ft. $3\frac{3}{4}$ in.

The best condition for the application of the load to the main levers will be when the load knife edge is directly under the center line of the rail. From center to center of rails is 4 ft. 11 in. Allowing $5\frac{1}{2}$ in. on each side of the center line of the lever, for the connections from the end of the main levers to the main, or load, knife edge on the extension levers, gives a lever 3 ft. long with a fulcrum of 12 in., the main lever ratio being 3.

BEARINGS AND KNIFE EDGES

Both the knife edges and the bearings against which they rest should be of high-grade tool steel, annealed, hardened and ground. Bearing surfaces must be generous and construction and materials of the best, other-

wise, the rough treatment administered to scales, such as the pounding due to the moving load and the tendency for the knife edges to corrode will lead to rapid deterioration. A load of 5000 lb. per linear inch of knife edge may safely be allowed, but this should not be exceeded.

The knife edges are of square, or flat, steel forged to a taper of not more than ¼ in. to one foot. If a smooth forging is made, very little, if any, finishing is required. After thoroughly annealing and hardening, the bearing edge is made true and keen by grinding and polishing, care being taken to have the faces of the bearing edge at an angle of not less than 90 deg. This edge must be straight in order to provide a full bearing along its length.

To insure a firm bearing in the levers, the knife edge seats are made in two ways. By skillful founding, the roughed forged knife edges are cast into the lever in their proper positions, and driven out for finishing, after the lever casting has cooled. This method is cheap, but it offers opportunity for misalignment. The preferable method is to broach, or slot, the seats, thus assuring accurate spacing and alignment, besides making the knife edges interchangeable. The knife edges should have sufficient metal backing to keep the unit bearing stresses low and prevent bending.

The design of the bearings against which the knife edges rest will differ according to the capacity of the scale. For the smaller capacities a direct and more or less non-adjustable bearing may be used; but where the capacity is large, a suspended, adjustable bearing is not only desirable, but necessary.

The bearings should be more or less self-aligning, vertical adjustment being provided by wedges over the main bearing, which have screw adjustment. The wedges are held securely in position by bolts which are drawn down after adjustment has been made.

The present practice for the bearings is to use an insert of steel, usually set in the mold before the casting is poured, as in the case of the knife edges, although interchangeability and accuracy can be more readily attained by machining the recess for the seat. Hardening is readily accomplished by withdrawing the steel insert from the casting. A true surface is obtained by grinding and polishing the steel while it is in the casting, care being taken not to draw the temper in the operation.

In the track scale, the dimensions of which are given in this paper, the approximate load upon the main knife edge of the main lever is 64,000 lb., which requires a length of knife edge of approximately 14 in. in order to keep the load below the specified 5000 lb. per linear inch. The butt knife edge will be 10 in. long, while the tip edge will be 5 in. long. The end extension lever will have the following knife edge lengths: butt 9 in., main 10 in., tip 1¼ in. The middle extension will be as follows: tip 1¼ in., main edge 5 in., bearing edge 9 in., and the tip nearest the fifth lever 2½ in. The fifth lever will be as follows: butt 5 in., main 5½ in., tip 1 in. The shelf lever knife edges need not be considered, because the theoretical lengths will not correspond to the finished article.

LINKS, LOOPS, SHACKLES, ETC.

All links, loops, shackles, and similar details should be designed stiff enough to prevent stretching, with consequent binding, which hinders ease of working. If the knife edge loops are not stiff enough, the load has a tendency to straighten the arch, which throws the load upon the knife edge at a point farthest from the support; the load being concentrated, produces excessive bending stresses, either bending the knife edge or snapping it (Figs. 3 and 4). Where knife edges are not reinforced, this bending must be considered, in

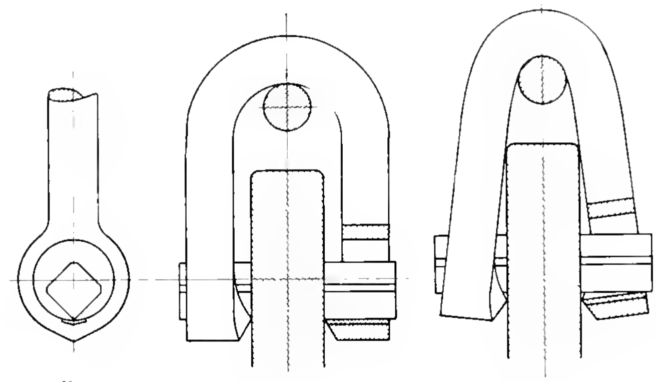

Fig. 3 Fig. 4

Fig. 3 Knife Edge Loop under Normal Conditions
Fig. 4 Knife Edge Loop under Abnormal Conditions

spite of the fact that the loop is made stiff enough to prevent stretching. A formula which seems to give satisfaction, is

$$P = 0.4\ Sd^2.$$

in which

P = safe working load, in pounds.
S = stress, per square inch.
d = diameter of iron, in inches.

It is advisable to use a good quality of wrought iron in preference to steel. Steel has a tendency to break without giving previous warning, while wrought iron will bend before breaking.

LEVER SECTIONS

The sections of the levers will next be investigated. It is necessary to consider stiffness more than strength. Too often a lever which is sufficiently strong from the standpoint of strength will deflect under load a noticeable amount, causing the ratio of the lever arms to change, giving inaccurate readings on the beam.

The main levers are to be steel castings, while the extension and fifth levers are to be made of structural shapes. The shelf lever may be either a forging or a casting. The beam is usually a casting, although foreign manufacturers do not hesitate to make it from a

forging. Since the levers are to be of steel, the allowable stress under repeated application of the load will be assumed to be 5000 lb. per square inch.

The maximum moment for the main lever will be about 600,000 lb.-in., requiring a section modulus of 120 (in.)^3. An I section 12 in. wide by 12 in. deep, having flanges and web 1 in. thick, will give a section modulus of about 135.3 (in.)^3, which is sufficient for all practical purposes. All knife edges are to be reinforced to prevent bending while under load. The depth of the lever will vary, tapering from the point of maximum bending moment toward the tip and butt, and the width of the flanges will decrease toward each end. The thickness of the flanges and web will be uniform throughout.

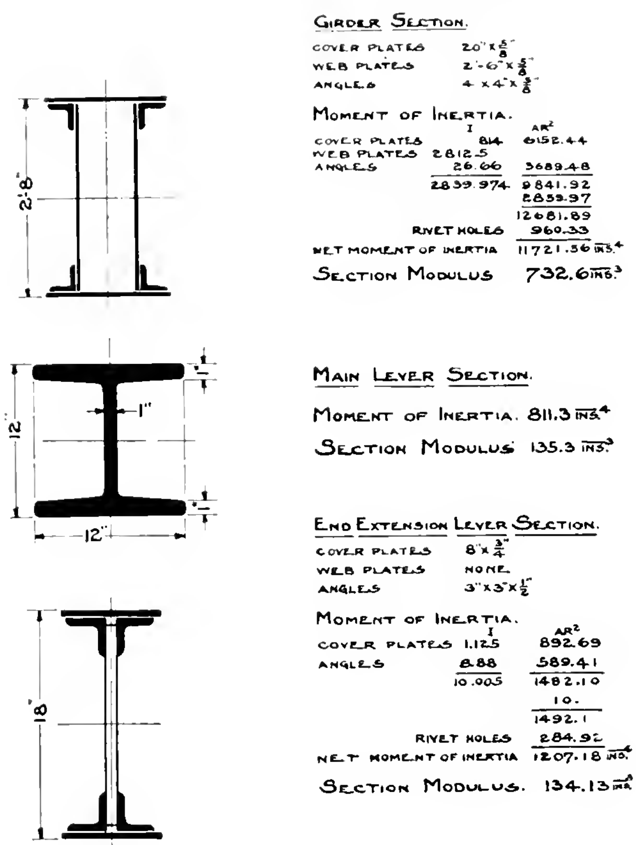

FIG. 5 SECTION MODULI FOR GIRDERS AND LEVERS

The maximum bending moment for the end extension lever will be 643,500 lb.-in., which requires a section modulus of 128.7 (in.)^3. A latticed section made up of cover plates 8 in. by $^3/_4$ in. and 3-in. by 3-in. by $^1/_2$-in. connection angles, gives a net section modulus of 134.13 (in.)^3, for a section 18 in. deep, due allowance having been made for $^{13}/_{16}$-in. rivet holes.

The maximum bending moment for the fifth lever tension lever will be 1,452,500 lb.-in., which requires a section modulus of 290.5 (in.)^3. A section 26 in. deep, composed of 8-in. by $^3/_4$-in. cover plates and 3-in. by 3-in. by $^1/_2$-in. angles, will give a section modulus of 306.11 (in.)^3 net, deduction for $^{13}/_{16}$-in. rivet holes having been made.

The maximum bending movement for the fifth lever will be 156,000 lb.-in., which will require a section modulus of 91.2 (in.)^3. A section 15 in. deep, composed of 8-in. by $^3/_4$-in. cover plates and 3-in. by 3-in. by $^1/_2$-in. angles, will give a section modulus of 106.64 (in.)^3 net, deduction having been made for $^{13}/_{16}$-in. rivet holes.

The maximum moment of the shelf lever will be 28,800 lb.-in., which will require a section modulus of 5.76 (in.)^3. A section 1 in. wide by 6 in. deep, will give a section modulus, gross, of 6 (in.)^3, or about 5.84 (in.)^3, when deduction for the knife edge hole has been made. This lever has a fulcrum of 12 in. and a length of 5 ft., its ratio being 5.

In all these computations, the dead load of the weigh bridge has been carried, a larger value than necessary having been chosen in order to be on the side of safety.

Range on each lever must be provided in order to compensate for unequal distribution of the metal about the knife edge line and any deflection that may occur. This range is accomplished by raising the main knife edge above a line through the tip and butt knife edges by an amount equal to $^1/_8$ in. per foot of fulcrum (see Fig. 7).

The main lever main knife edge will be allowed a range of $^1/_8$ in., as will also the extension levers, while the fifth lever will have a range of $^3/_{16}$ in.; the shelf lever will be given a range of $^1/_8$ in., while the range on the beam is almost negligible, less than $^1/_{16}$ in., yet it must be considered.

A resumé of levers will be useful (see Figs. 5 and 6):

LEVER	M MAX.	SEC. MOD.	SECTION
Main.	600,000	135.3	Cast steel I
End extension .	643,500	134.13	2–8 in. by $^3/_4$ in. pl, 4–3 in. by 3 in. by $^1/_2$ in. Ls—18 in. deep
Middle extension.	452,500	306.11	4–8 in. by $^3/_4$ in. pl, 4–3 in. by 3 in. by $^1/_2$ in. Ls—26 in. deep
Fifth	456,000	106.4	2–8 in. by $^3/_4$ in. pl, 4–3 in. by 3 in. by $^1/_2$ in. Ls—15 in. deep
Shelf.	28,800	5.84	6 in. by 1 in. steel or W. I.
Beam. . . .	3,000	1.00	3 in. by $^3/_4$ in. steel or W. I.

GIRDERS

The middle span of the weigh bridge will be subjected to a live load of 100,000 lb. passing over it; the end spans, particularly the one at entrance, will be subjected to impact, due to the moving load dropping from the dead rails to the live rails on the weigh bridge, or the wheel striking the end of the rail, due to a difference in level, or a gap, between rail ends. While a condition of unequal levels is not desirable, yet, wear, settlement, along with frequent repairs, cause inequalities in alignment.

As noted before, there will be an objectionable pounding upon the knife edges if a continuous girder is used, due to the deflection of the weigh bridge upon application of the load, so the bridge will be subdivided into three parts, the joints coming over the main bearing stands of the main levers; each girder will be made stiff enough to resist deflection due to the applied load.

The greatest bending comes upon the middle span;

for uniformity and quickness in assembling, the girder sections for end spans will be the same as for the middle span.

The girders should be designed for stiffness, so a permissible deflection of $^3/_{32}$ in. will be assumed. The deflection formula for a beam supported at the ends and loaded at the middle is

$$\varepsilon = \frac{1}{48}\,\frac{PL^3}{EI} = 0.02083\,\frac{PL^3}{EI}$$

$$I = 0.02083\,\frac{PL^3}{E\,\varepsilon}$$

Using a modulus of elasticity of 25,000,000 lb. per sq. in. and limiting the deflection to $^3/_{32}$ in., we have

$$I = 0.02083 \times \frac{50{,}000 \times (283)^3}{25{,}000{,}000 \times \frac{3}{32}}$$

$$= 10{,}080\ (\text{in.})^4$$

It will be interesting to compare this result with what would have been obtained if the fundamental formula for bending had been used, with the stress due to suddenly applied loads.

From tests on the fatigue of steel under repeated loading, by Wöhler and Spangenburg, and the later tests by Bauschinger and at the Watertown Arsenal, the following formula may be used in finding the proper safety factor to be used for variable loading of an indefinite number of repetitions:

$$F_2 = \left(2 - \frac{P_2}{P_1}\right) F_1$$

in which

- F_1 = safety factor under static loading.
- F_2 = corresponding safety factor under a loading that varies, repeatedly, between the limits P_1 and P_2.
- P_1 = greatest pressure due to the variable load, to be taken as plus (+) if causing tension and minus (—) if causing compression, in the most strained fiber of the member.
- P_2 = least pressure due to the variable load, to be taken as plus (+) if causing tension and minus (—) if causing compression, in the most strained fiber of the member.

This formula is applicable to the case of steadily applied loads as well as to the cases in which the load varies from O to P_1, and P_2 to P.

Since, for any given material, the working fiber stresses for the different conditions of variable loading are inversely proportional to the corresponding safety factors, it is apparent that the formula may be put in the following form:

$$f_2 = \frac{f_1}{2 - \dfrac{P_2}{P_1}}$$

in which f_1 = working fiber stress, under static loading, in pounds per square inch.

f_2 = corresponding working fiber stress under a load that varies repeatedly between the limits P_1 and P_2, in pounds per square inch.

P_1 and P_2 have the same signification as noted before.

For the case where the load varies from O to P_1, the formula becomes

$$F_2 = \left(2 - \frac{O}{P_1}\right) F_1 = (2 - O)\,F_1 = 2\,F_1$$

or

$$f_2 = \frac{f_1}{2 - \dfrac{O}{P_1}} = \frac{f_1}{2}$$

which indicates, for a suddenly applied load, indefinitely repeated, that the safety factor should be twice that for static loads, under otherwise similar conditions.

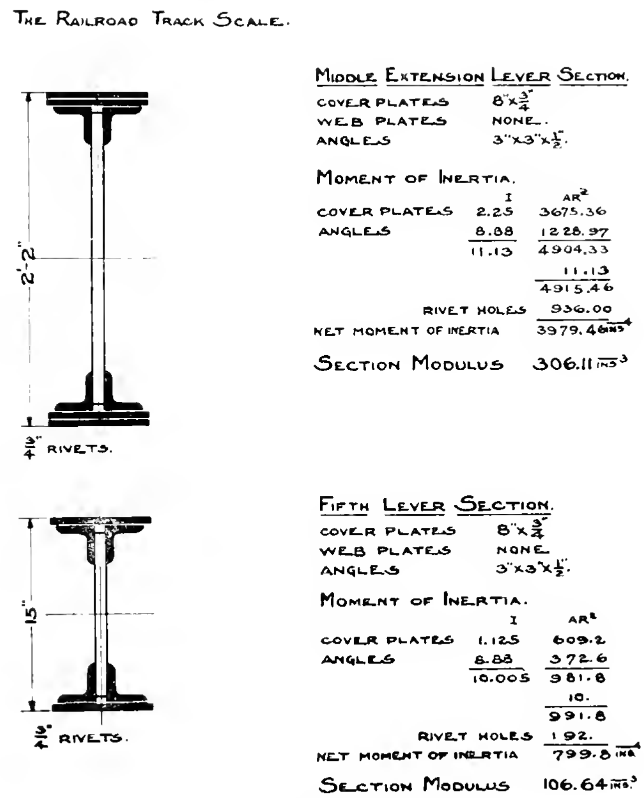

FIG. 6 SECTION MODULI FOR LEVERS

The maximum bending moment for the end spans will be

$$\frac{50{,}000 \times 214.5}{4} = 2{,}681{,}250 \text{ lb.-in.}$$

The maximum bending moment for the middle span will be

$$\frac{50{,}000 \times 283}{4} = 3{,}537{,}500 \text{ lb.-in}$$

The customary stress for bridges, subjected to live loads, is about 12,000 lb. per sq. in. The formula developed indicates that half this stress should be allowed; so, using a stress of 6000 lb. per sq. in., we have a section modulus of

$$\frac{I}{c} = \frac{M}{S} = \frac{3{,}537{,}500}{6000} = 589.6 \text{ (in.)}$$

against a section modulus of 630 (in)^3 (considering a section 32 in. deep) derived by the flexure formula. Only too often, girders are designed without due regard to stiffness, or the effect of loads suddenly applied, with very apparent deflection when loaded.

Using a section 32 in. deep, composed of two 20-in. by $\frac{5}{8}$-in. cover plates, two 30-in. by $\frac{5}{8}$-in. web plates and four 4-in. by 4-in. by $\frac{5}{8}$-in. angles, and deducting for $\frac{15}{16}$-in. rivet holes, we have a net moment of inertia of 11,721.56 (in.)^4, which gives a section modulus of 732.6 (in.)^3, well within what is required.

To prevent buckling of the web, reinforcing angles are spaced at intervals along the girder. Over the supports, sufficient angles must be used to carry the load, considering the angles as a column. Gordon's formula for columns with square bearings is:

$$P = \frac{a}{f}\left[\frac{50{,}000}{1 + \frac{1}{36{,}000}\left(\frac{12\,L}{r}\right)^2}\right]$$

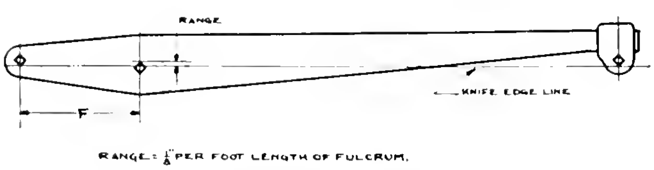

FIG. 7 RANGE IN LEVERS

in which

P = load to be supported, in pounds.
a = sectional area of column, in square inches.
f = safety factor.
L = unsupported length of column, in feet.
r = least radius of gyration, in inches.

The load to be supported is 50,000 lb. plus about 20,000 lb. for the weigh bridge. Using two angles in each column, each angle can be assumed to carry a half of the imposed load, or 35,000 lb. The formula then reduces to

$$35{,}000 = \frac{a}{8}\left[\frac{50{,}000}{1 + \frac{1}{36{,}000}\left(\frac{29\frac{1}{2}}{r}\right)^2}\right]$$

$$280{,}000 = a\left[\frac{50{,}000}{\frac{r^2 + 0.024}{r^2}}\right]$$

$$28r^2 + 0.677 = 5ar^2$$

But

$$I = ar^2$$

$$I = 5.6r^2 - 0.135$$

Using a 4-in. by 4 in. by $\frac{5}{8}$-in. angle with a moment of inertia of 6.66 (in.)^4 the resulting radius of gyration is 1.067 (in.), while that from the table is 1.20 (in.). The area deducted for rivet holes will be more than made up by the 4-in. by $\frac{5}{8}$-in. fillers which are necessary. Judicious spacing of 4-in. by 4-in. by $\frac{5}{8}$-in. angles will go a long way toward stiffening the web and preventing it from buckling.

To prevent the girders from becoming displaced, and to hold them in proper alignment, each end of the middle section should be extended in such a way that the extension will telescope into the end of the end girders; and a tie plate should be riveted to the bottom plates of the girders, at the joint, in order to make a rigid connection horizontally and yet allow each girder to deflect, independently, vertically. In this way, freedom of movement for deflection is obtained, and the objectionable bending over the supports, which occurs in continuous beams, is eliminated. With each span deflecting with freedom, there will be no lifting from, or dropping upon, the knife edges, as the load passes from one span to the other.

THE BEAM

The beam is to be of the full capacity type, the main bar being graduated in thousands of pounds, and the fractional bar in hundreds of pounds, to a thousand, by tens. Assuming an index of graduation of 5 to the inch for the main bar, a run of 5 ft. will include a capacity of 300,000 lb., while an index of 10 to the inch for the fractional bar will give a run of 10 in.

With a fulcrum distance of 5 in. on the beam, the main poise will weigh

$$W = \frac{C\,F}{R\,M} = \frac{300{,}000 \times 5}{60 \times 1000} = 25 \text{ lb.}$$

and the fractional poise will weigh

$$W = \frac{1000 \times 5}{10 \times 1000} = \tfrac{1}{2} \text{ lb. or 8 oz.}$$

where

W = weight of poise in pounds or kilograms
C = capacity of scale in pounds or kilograms
F = fulcrum distance of beam, inches or centimeters
R = run of poise, inches or centimeters
M = ratio at butt of beam

If the beam is cocked, that is, flies all the way up or all the way down, and indicates a true balance only when the load indicated on the beam is exactly that on the platform there may be two faults: either too much weight above the knife edge line, or too much range.

Obviously, if there is too much metal above the knife edge line, the remedy lies in placing sufficient below to counteract its influence. In order to correct such troubles readily and avoid the useless addition of metal, it is usual to arrange the balance ball so that it can be placed in a position to correct this fault. The difficulty, due to too much range, is eliminated by reducing the range until it has disappeared. Slowness of action is very often caused by dull knife edges, unnecessary friction, too much metal below the knife edge line, or no range; eliminate the cause and the effect produced will disappear.

Since the beam has a fulcrum distance of 5 in., the total pull on the butt of the beam will amount to 600 lb., which gives a maximum moment of 3000 lb.-in., requiring a section modulus of 0.6 (in.)^3, which is satisfied by a section $\frac{3}{4}$ in. wide by 3 in. deep, deduction having been made for the knife edge hole. The trig loop is placed at the tip of the beam and the precaution to have the trigger down whenever a load is entering upon the live rails will save the beam many hard jolts and prolong its accuracy.

More details of the beam will be useful. For rapidity of weighing the fractional poise will be mounted upon the main poise so that the latter will include the weight of the fractional poise, its beam, and any other details that may be necessary.

The main beam will be notched for each thousand pounds, and each notch accurately sealed, indexed and marked. The index and marking should be cut quite deep, because the service which most scales undergo is not of the best and seldom is much attention given to polishing and cleaning the beam or otherwise keeping it in order. The fractional beam will not be notched, due to inconvenience where quick weighing is desired.

The knife edges should be of square steel, the bearing edge being ground and polished to a true edge, which must be hard and sharp, clean at all times, to assure accurate and sensitive weighing.

Projections upon the beam, or poises, are not desirable. Dirt rapidly accumulates and destroys the accuracy of the scale. Likewise, openings of any kind offer opportunity for dirt to accumulate or weight to be surreptitiously extracted from the poise. In other words, anything that can be conscientiously done to promote accuracy in weighing must be done; it is preferable to leave no detail incomplete.

The beam stand must be built solid enough to withstand the shock of the suddenly-applied load. From the point of safety it is desirable to keep the beam as far as possible from the track, but too great a distance means a long lever, which is objectionable, due to the increased depth necessary to get the requisite strength and the consequent increase in weight. Cars average close to 10 ft. in width at the eaves; whether this width may be exceeded or not is due to clearance limitations on certain roads; at any rate, future expansion must be provided for. Allowing five feet between the side of the car and the building and about four feet from the outside of the wall to the reach rod from the tip of the fifth lever to the shelf lever, we have a fifth lever of 14 ft. 3 in. long, a ratio of 8 giving a fulcrum distance of 19 in. and a long arm of 12 ft. 8 in., this lever being of the first class.

PLATFORM, BRIDGE AND RAILS

A platform of such great size and weight as required for this scale should have ample clearance and be entirely free of any movement of the weigh bridge to prevent binding at any point due to the accumulation of dust and dirt. To provide proper clearance the pit will be made 10 ft. wide. To support the platform I-beams spaced at proper intervals will be used. The greatest load that can come upon one I-beam will be the load upon one axle and the maximum moment will be when the wheels just straddle the center line of the scale; this moment will be about 825,000 lb.-in., a 15-in.-42-lb. I-beam being sufficient.

To make the platform durable concrete should be used. With this construction repairs are infrequent and not very costly; a tight cover for the pit is assured.

The bridge, through its bearings, rests freely upon the main lever knife edges, there being no rigid connection between them. To prevent the bridge from sliding, a system of lateral and longitudinal checks is provided. These checks should be made as long as possible in order to prevent binding when the bridge deflects, while under load; the theory is, the longer the check, the more nearly the short path described approaches a straight line.

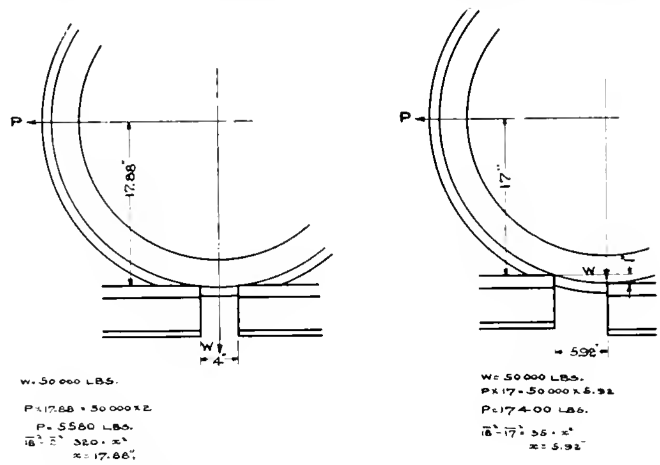

FIG. 8 DIAGRAM SHOWING RAIL CONDITIONS AT ENTRANCE

The load applied to the checks is caused in several ways, any one of which may occur. The end of the live rail may be some inches from the solidly laid dead rail, so that a blow is administered to the end of the live rail as the wheels enter upon it. Another condition is due to adhesion, or friction, between the wheels and rails when the brakes are applied. Still another condition, similar to the first, is a difference in the level of the live and dead rails, the worst blow coming when the live rail is above the dead rail. Probably the worst situation is when the first two, or last two, occur at the same time. This will come about when three pairs of wheels are on the live rails, the fourth pair just entering, all brakes set and the last pair striking the ends of the live rails. The conditions brought about by rail inequalities are indicated in Fig. 8.

The pressure, due to the friction between the wheels and rails, when the car is suddenly stopped, depends upon the speed of the car. Assuming a speed of 5 miles per hour, the thrust will be

$$P = \frac{W}{g} \times \frac{V}{T}$$

The coefficient of adhesion for dry sanded rails is 0.25, so

$$P = \frac{50{,}000 \times 0.25}{32} \times \frac{5 \times 5280}{60 \times 60} = 2865 \text{ lb.}$$

This value is for one pair of wheels; for three pairs, the result will be 8595 lb., which is the thrust delivered to two longitudinal checks, or a thrust of 1297 lb. to each one.

Assuming a gap of 4 in. between rail ends, and a 36-in. wheel, the force of the blow will be

$$P = \frac{2 \times 50{,}000}{17.88} = 5580 \text{ lb.}$$

delivered to the two longitudinal checks, or a thrust of 2790 lb. to each check. If there is a difference in level of 1 in., the blow would be very much aggravated, as is indicated below.

$$P = \frac{50{,}000 \times 5.92}{17 \text{ in.}} = 17{,}100 \text{ lb.}$$

delivered to both longitudinal checks, or 8700 lb. to each check.

The total highest thrust will be due to the sudden stopping of the car on the live rails and the wheel striking the end of the rail when the live rail is higher than the dead rail, which amounts to 13,000 lb. Using a stress of 7500 lb. per sq. in., a round bar $1\frac{1}{2}$-in. diameter will be sufficient. In order to provide adjustment, the check will be provided with a turnbuckle; accordingly, the end of the bar will be upset for a $1\frac{3}{4}$-in. thread.

The lateral checks serve to prevent side motion, so for the sake of uniformity, they will be made of the same stock as the longitudinal checks. In order to prevent binding, the checks should fit the check pins with freedom, and sufficient slack provided to allow, say, $\frac{1}{16}$-in. movement—just enough to allow the checks to be free when there is no load upon the scale.

The rails are carried upon stands which are fastened to the bridge girders. These stands must be rigidly fastened to the girder and able to withstand much abuse, due to derailments. To hold the rail firmly, suitable clamps must be used, which have not the bad habit of working loose in service.

A dead rail has not been considered, it being preferable to provide a relief mechanism, or pass cars and locomotive around the scale on another track. Dead rails offer too much temptation to an engineer to use the live rails for shifting, etc., as is very often done.

The high axle loads of the locomotives now in use are often beyond the capacity of the scale and such excessive loads must not be allowed to pass over the weigh bridge.

While the scale is designed to withstand considerable misuse and much neglect, yet this provision does not mean that the abuse may be continued with entire safety. The metal will fatigue, eventually, and possible costly repairs result. When the design of a track scale is considered, it must be borne in mind that stiffness in construction, coupled with lightness of moving parts and absence of friction, is to be desired.

Upon the scaler depends the accuracy and dependability of the weights indicated. Inspection should be frequent and thorough in order to detect and repair any damage that may have occurred through age or abuse. It is always preferable to have sufficient foresight to prepare for an emergency and, if possible, prevent a breakdown which may cause serious trouble.

Too much stress cannot be laid upon the honest and conscientious performance of the responsibility laid upon the weigh master. The public no longer tolerates tampering with weights; they have demanded honesty and show their earnestness of purpose by the many legal enactments and the frequent prosecution of offenders.

NECROLOGY

MAX JULIUS ULRICH

Max Julius Ulrich, designer in the oil engine department of the De La Vergne Machine Company, died July 27, 1914, after a three days' illness.

Mr. Ulrich was born at Halle, Germany, February 8, 1856. He was educated at the Royal Technical Institute at Halle and graduated from the Polytechnic Institute at Karlsruhe. He served an apprenticeship to Emil Stahrer at Leipzig from 1870 to 1873, and from 1873 to 1874 was spent in the drawing room of W. Uhland at Leipzig. He later spent a year in shop experience with Sachsenberg Brothers, Rosslau, in building mining machinery, and from 1879 to 1881 was designer for Messrs. Haddick & Roethe, pump-builders at Weissenfels, Germany.

After this, he came to the United States, and in 1882 became superintendent and mechanical engineer of the Ulrich Engine Company of Florence, Massachusetts, where he remained until 1894. During this time he invented a cut-off motion for duplex steam pumps which was patented in the United States, England and Germany. From 1892 to 1894, he served also as designer for the Deane Steam Pump Company, at Holyoke, Massachusetts. In 1894, he became chief draftsman of the Deane Company and held this position, with the exception of three years' absence, until 1901. During the period from 1900 to 1902, he also wrote two courses for the International Correspondence Schools in hydraulics and pumping machinery design.

In 1902 he came to New York as chief draftsman for the Alberger Condenser Company, which position he retained until 1912. His first undertaking here was the designing of the condensers installed in the 59th Street power station of the New York Subway, by the Alberger Company.

On December 15, 1912, he became designer in the oil engine department of the De La Vergne Machine Company, and held this position at the time of his death.

Mr. Ulrich was a member of the Verein deutscher Ingenieure and was a prominent Mason.

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

In the first section, on Aeronautics, will be found data of tests concerning the action of wind on a plane of an aeroplane under dynamic conditions, that is, produced by a blast of which the direction and intensity vary rapidly. In the next section, on Fuels and Firing, are reported data on a German smokeless boiler furnace, and on peat testing. It appears, among other things, from this article that serious attention is being paid to the development, on a strictly scientific basis, of the peat industry in Europe and that promising progress in this direction has been already made. The section on Gas Engineering is closely connected, in some of its features, with that on Fuels. Rummel, in the Journal of the German Society of Engineers, discusses the use of gas in metallurgical plants where it is obtained as a by-product of the operation of blast furnaces and coke-ovens, and, after a thorough consideration of all conditions, comes to the conclusion that the least economical method of consuming the gas is by burning it under boilers, notwithstanding the fact that, as the author states, there are many cases in these plants where steam drive is still the best.

A number of interesting papers are abstracted from the report of the last meeting of the French Gas Technical Society, such as on storage of coal under water; on a new construction of a centrifugal tar separator; on an apparently anomalous phenomenon in the purification of gas by iron oxide; on comburimeters; corrosion of cast iron piping; safety valves for gas meters, and improved formula for the calculation of gas conduits.

From a description of a hydro-electric installation in French Northern Africa are taken data on the Minetti speed governor used in connection with large Francis water wheels. In the next section, Internal Combustion Engineering, are described a number of cooling devices used on internal combustion engines of various makes, as well as a novel construction of steel cylinders. The latter presents a good deal of interest to the American makers of automobile and, perhaps still more, of aeroplane engines, as a steel cylinder, while as reliable as a cast iron one, is at least half the weight of the latter.

In a former issue was described a chain pump of novel construction invented by a French engineer, Bessonet-Favre. It appears that it has been since introduced commercially, and in the present issue we are able to present some data on output and power consumption of these pumps. We are also able to present in this issue data of tests of a Wefer gas fired furnace which has been described in detail in a former issue; the plant, with this type of furnace, has shown a total efficiency of 84.6 per cent.

A brief abstract of the article of Professor Mérigeault on the theory of the Tesla turbine gives data on possible improvements in this type of apparatus, while the next article presents information on the actual conditions of operation of the apparatus which has become lately known under the name of ejectair (first described in the English language in an abstract in the Foreign Review). In the section on Miscellanea will be found data on tests of a mixture of mineral oil and oildag, showing that the presence of the latter material insures a saving in lubricant.

New specifications published by the Association of American Steel Manufacturers are given covering structural and boiler steel, concrete reinforcement bars rolled from billets, and rail steel concrete reinforcement bars. From a paper before the Engineering Association of the South is taken an abstract concerning the Nashville Smoke Ordinance, one of the features of which is that it permits a rather large amount of smoking. Interesting data on the relative thermal efficiencies of steam and producer gas plants will be found in the abstract of R. H. Fernald's paper before the Franklin Institute on Producer Gas from Low Grade Fuels, while a new development in surface combustion boilers, and data of tests of this type of steam generators are described in a paper on the Bonecourt Boiler published by the Institution of Electrical Enginers (London).

W. A. Converse, in a paper before the Railway Club of Pittsburg, considers some ill effects of boiler feed waters from the point of view of the analytical chemist, and throws a good deal of light on some phenomena which cannot be said to be generally well understood, such as, e.g., the relation between presence of scale and corrosion.

Other abstracts refer to the flow of metals under large constant stresses.

FOREIGN REVIEW

Aeronautics

Action of a Rapidly Varying Wind on a Wing of an Aeroplane (*Effet exercé sur une aile par un vent rapidement variable*, Professor A. Lafay. *La Technique moderne*, vol. 8, no. 9, p. 329, May 1, 1914, 3pp., 4 figs. *eA*). Tests made on models of aeroplane wings or on actual supporting planes are as a rule exclusively static and the blast of air produced by the blower and used for the test is maintained in a permanent state during the duration of each test. In this case, an attempt was made to study the same cases under dynamic conditions, that is, to investigate the variable stresses produced by a blast, the direction and intensity of which vary rapidly. For this purpose, a special aerodynamometer has been constructed in which very feeble elastic deformations are used to balance the force applied. The latter can be evaluated by means of optical amplification. With this apparatus, it has been found that when the wind jumps at an amplitude of twenty degrees in less than a 0.1 second, the stress exerted at any instance differs not more than by one tenth from that which corresponds to a permanent state of operation, with the same intensity and direction of blast as prevails at that instant. If one considers the relative motion of the flying element with respect to the air, it follows from this that one may deduce from suitably arranged static tests, the data necessary for the calculation of the stresses produced in the apparatus under given stresses such for example as those which arise when an air-ship straightens rapidly after a jump or during its entrance into an ascending or descending current of air.

Fuels and Firing

Smokeless Boiler Furnace (*Eine rauchlose Kesselfeuerung*, v. Pasinski. *Rauch und Staub*, vol. 4, no. 9, p. 137, June 1914. 3 pp., 2 figs. *ae*). The article describes what is claimed to be an absolutely smokeless boiler furnace which in addition is very economical with respect to fuel consumption under various conditions including overloads. This is the Gartner furnace, shown in Fig. 1A. It has neither special stoking apparatus nor complicated mechanism for regulating the firing. The system represents a type of extended furnace with a trough grate, the coal falling through an inclined shaft from laterally located bunkers onto the grate trough. It undergoes, at the edge of the trough, a preliminary gasification, and is then perfectly gasified by sliding down towards the middle of the grate. Over the grate at a sufficient height and directed towards the boiler, is placed an arch structure; as a result there is a large fire chamber which permits not only the free development of the flame of coal rich in volatile matter but also facilitates combustion through the heat radiated from the arch. However favorable these conditions may be for good consumption, there must be also a liberal admission of preheated air of combustion, and this is effected by making the air enter the wide passages (Fig. 1B) over the arch of the fire chamber where the air is preheated and reaches the vertical passages of the front (under the grate) while it is quite hot.

In order to make this firing as adaptable as possible to various conditions of operation, a sidestrip of the grate is provided with a separate air admission which may be shut off by a valve shown in Fig. A, and in this way it is possible to vary the active grate area of 1.8 qm (19.3 sq. ft.) without interfering with the process of combustion, by about twice 0.5 qm or 5.3 sq. ft. This side section of the grate having its separate air admission, can be operated also on compressed air which gives a further possibility of overloading the furnace and makes it particularly adaptable for meeting practical requirements. When it is desirable to burn coals very rich in volatile matter, the side arches are provided with double air admission, which may be also cut off by means of a valve. Several tests have been carried out and it was found that as a rule the furnace operated absolutely without any smoke except when it was being cleaned. The author claims also that the saving in coal as compared with the former horizontal grate installation amounted to as high as 29 per cent.

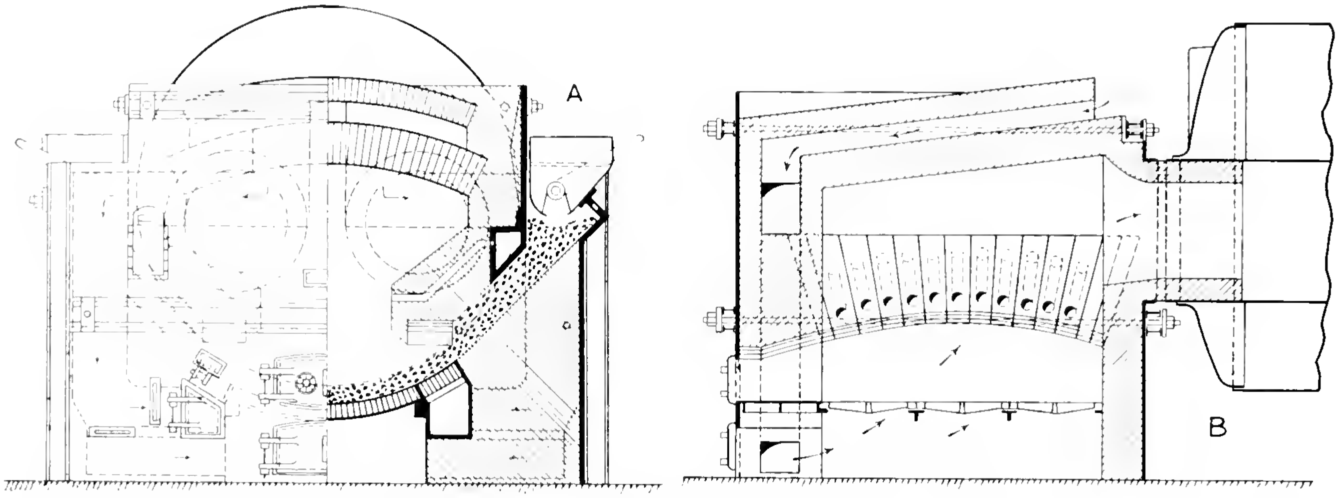

Fig. 1 Gartner Smokeless Boiler Furnace

Contributions Towards the Construction of Scientific and Technical Foundations of the Peat Fuel Industry (*Beiträge zum Aufbau der wissenschaftlich-technischen Grundlagen für die Brenntorfindustrie*, Professor C. Blacher and W. Duglas. *Feuerungstechnik*, vol. 2, no. 19, p. 321, July 1, 1914, article not finished. *et*). The authors present the first report of the laboratory of chemical technology of the Technical High School in Riga (Russia) on the subject of the establishment of scientific and technical foundations for the peat fuel industry. This is a subject of considerable importance in view of the lack of data for the determination of the peat value of bogs. Hitherto, some of the best classificators, such as Walgrens, limited themselves to such expressions as "very good," "bad," "very pure," "very impure," etc., without, however, giving a precise basis for the determination of the fuel value of the material and it is just with respect to the determination of the ability to form peat that an exact method of classification is very desirable. The authors have tried to derive such a method on the basis of the solubility of the humus substances in a solution of caustic potash and the determination of that part which remains insoluble in this reagent. This method would, however, not be convenient on account of the long time taken in the filtration of the caustic potash and the formation of the deposit, as well as on account of the fact that air-dried filters must be necessarily used. It was, therefore, found to be more convenient to use the colorimetric methods and to determine the color of the solution obtained by soaking the peat in a solution of caustic potash. The value, with respect to peat formation, was expressed by the percentage of humus acids or humus substances. In this case by 100 per cent was denoted a solution of the humus substances which after extraction by caustic potash solution and by hydrochloric acid appeared as speck peat. When both methods, the quantative and the colorimetric were compared, it was found that substances soluble in caustic potash gave different values, which would indicate that the caustic potash solution dissolved, in addition to coloring substances, a considerable amount of non-coloring substances, and it is yet a difficult

question to say whether these latter non-coloring substances have any value in the formation of peat fuel. The adaptability of the colorimetric method for the estimation or humus content of peat, for the purpose of determinating fuel value, is an open question until it has been determined which substances give strength to peat formation, that is, which of the irreversible colloids soluble in water give to peat the gel similar to that found in the constitution of coal.

Since, however, the final purpose of the investigation is to determine the amount of peat formed from a given extraction, it is, for that particular purpose, actually indifferent where the percentage value obtained represents actual contents of the important heat substances or gives purely empirical values representing an increase of these substances during the process of peat formation. What is necessary, is to obtain some process which under similar circumstances, would always give similar values. After numerous tests, the following process has been worked out: 0.2 g. of water-free peat were covered with 50 cu. cm. of water to which were added 3 cu. cm. of a 50 per cent potassium solution. The whole boiled for an hour and the water level maintained by additions of fresh water. This was cooled and poured into a graduated glass, filled up to 100 cu. cm. and poured directly into a filter of 1815 cm. Out of the filtrate so obtained, 20 cu. cm. and in case of very dark liquid 10 cu. cm. were poured into a 250 cu. cm. vessel filled with water. The solutions so obtained which were all of quite different colors were then compared first with one another and then with the standard solution in order to obtain the percentages showing the contents of humus substances in the peat. The colorimetric determination has been done in a Wolf colorimeter. In the course of these tests, it proved possible to determine the degree of peat formation in various parts of a bog and it was found that as a rule a more complete peat formation was found in the deeper parts of the bog where the layer was darker in color, while elsewhere the layer containing large amounts of ash was poorer in humus. During these tests, it was found that the color of alkaline humus solutions was not permanent and on this account investigators resorted to the Russian standard solution used for the analysis of sewage waters, and prepared in the following manner: 10 g of Fe_2Cl_6 and 2.5 g of $Co\ SO_4\ 7\ H_2O$ together with 10 cu. cm. of concentrated hydrochloric acid were dissolved in a liter of water and 100 cu. cm. of this solution passed into a vessel of the Wolf colorimeter. In the other vessel was placed the solution the value of which was investigated and the column of liquid was reduced until its color corresponded to that of the 100 cu. cm. standard solution. The authors attempt to express the factor of climate numerically and further proceed to a brief consideration of the use of peat as a domestic fuel. (This Article is not Finished)

Gas Engineering

The Gas System of Metallurgical Plants (*Die Gaswirtschaft auf Eisenhüttenwerken*, A. Rummel, *Zeits. des Vereines deutscher Ingenieure*, vol. 58, nos. 29 and 30, pp. 1153 and 1216, July 18 and 25, 1914. 13 pp. *gp*). The present article investigates what the author calls a gas system of a metallurgical plant, that is the methods of production and utilization of gas obtained in connection with the various primary operations of the plant. It is to a considerable extent of descriptive nature and naturally has reference almost exclusively to German conditions. In the main, the author points out the great development of the utilization of gas in metallurgical plants which has taken place of late. It is very difficult in many cases to determine what is the most economical way of utilizing the gas obtained and each particular case in every work has to be determined in connection with the local conditions existing therein. It is a good plan to consider for this purpose each coke-oven plant or blast furnace as an independent manufacturer striving to sell his gas, even though a by-product, at the best price obtainable. On this basis, a system may be developed for establishing the values at which the gas may become available for different purposes, the prices of the gas thus determined not being necessarily the same in each case. This method of considering the gas producing sections of the plant as private and independent enterprises, is both convenient and productive of good results. The different users of gas in the plant can pay for the gas a price only high enough to enable them to work with it at rates not more expensive than if they were using some other fuel available, for example, coal. The author makes his comparison mainly, therefore, on the basis of a comparison of the cost of 1000 calories in good coal and a similar amount of heat units in gas. In so far as examples taken from actual practice permit of drawing conclusions as to general rules, it appears that in the normal case it is the most economical system to consume the gases produced by blast furnaces, in the power-house of the plant; in the first place for producing the blast, in the second, for current generation, and, finally, for driving the gas blowers of the steel mills. Next comes the use of gas as fuel in the steel mills and rolling mills, as well as for the auxiliary plants such as tempering, heating, and so on. It is only when there is absolutely no other way of utilizing gas that it may be burned under boilers which appears to be by far the least economical methods of its utilization. The coke-oven gases can best be utilized for lighting purposes, next, in gas engines, then in open hearth furnaces, and finally, in the least economical manner, under boilers. With these conditions in view, it appears that in the metallurgical plant the gas engine is substantially superior to the steam turbine, no matter how the steam for the turbine is generated, that is, whether gas fired or coal fired boilers. It is not meant of course that steam is not to be considered as a prime mover for metallurgical plants. The author points out where the steam can be used with advantage and what disadvantages there are in its use. Exhaust steam turbines have not proved successful in metallurgical plants, and the main consumer of steam is found to be the rolling mill whose steam requirements vary with great rapidity and with extreme irregularity. This produces an extremely economical operation on exhaust steam turbines, even with large steam receivers. The double pressure turbine on the other hand would be well adopted mechanically, but has too high an initial cost. On the other hand, the steam turbine in a power plant has the advantage of being able to take large peak loads. The author recommends therefore to use the excess of gas, between the actual gas production and the requirements of the gas driven apparatus in the plant, as fuel under boilers which should be equipped in such a manner as to be able to utilize either coal or gas indifferently. The steam produced in such a manner can be very widely utilized and as shown above, there are many cases where steam machinery properly selected is

cente suitable to metallurgical work. The author, after investigating the proper methods of determining the price of a kilowatt, comes to the conclusion that in many cases, steam is preferable for heavy rolling mill drives.

Forty First Congress of the (French) Gas Technical Society (*XLIe Congrès de la Société Technique du Gaz. Le Génie Civil*, vol. 15, nos. 10 and 11, pp. 192 and 217, July 4 and 11, 1914, 6 pp., 5 figs. *gde*). The forty-first Congress of the Gas Technical Society of France was held in Paris in June 1914, the regular practice being to hold the Congress one year in Paris and the next year in one of the larger provincial cities. A number of interesting papers have been presented. Rolland d'Estape reported his experiments on the behavior of coal previously stored under water in storage bins and in furnaces. The experiments were carried out with English coal stored in a reinforced concrete cylindrical silo 10 m. (32.8 ft.) high and 4000 cu. m. (141250 cu. ft.) capacity containing about 3200 metric tons (3520 short tons) of coal. The entire structure was above the ground in such a manner that both the water and the coal could be drawn out by gravity. Preliminary experiments have shown that (1), coal kept at a certain depth absorbs only quite negligible quantities of water, and (2), that the quantity of water retained by adherence is proportional to the fineness of the coal (15 to 20 per cent with fine coal and 1.5 per cent in the case of lumps 35 to 50 mm., or 1.4 to 2 in. in size). The coal cannot be dried by simply letting the water run off. It was found that, when special valves are opened, the water contained in the silo runs out in ten and a half hours but drippage continues to flow at the rate of about 30 liters (7.9 gal.) per minute for the first hour and at the rate of ½ liter (0.13 gal.) per minute after fourteen days. The silo was filled up to two-thirds of its height with run-of-the-mine coal, containing 40 per cent of breeze, and in the upper third with three separate lots: run-of-the-mine, lump coal, and run-of-the-mine cleared of dust. Sample quantities of 20 tons each were taken from each of the three lots of coal. The run-of-the-mine coal which contained 9.8 per cent of water when coming out from the silo three days later contained only 6.2 per cent when it reached the distilling rooms, while in the large lumps humidity has gone down 3.6 and even 2.8 per cent. The 600 tons of coal distilled during these experiments have not caused any appreciable fall in the temperature of the furnaces. Calculation shows that vaporization of 6 kg. of water per 100 kg. of coal ought to increase by about 1.5 per cent the combustion of fuel. Since the coal stayed in the silo for only a short time no difference was found in either the quantity or quality of the gas obtained with dry or wet coal.

Mazeran described a *centrifugal tar separator* having no movable parts, provided with two cells, and based on the same principle as the so-called cyclone apparatus. If one imparts to raw gas a rotary motion in a cylindrical space into which it is admitted tangentially with a large fall of pressure, the action of the centrifugal force brings about the separation of tarry particle which enlarge by hitting one another, and are finally projected on to the periphery, owing to the difference of density between the condensed tar and gas. The growth of the tar particles occurs in the first cell *A* (Fig. 2A) and the main separation in the second cell *B* into which the gas flows from the center to the periphery. Previous failures of similar apparatus was due to working on variable output, as a result of which, it often occurs that the velocity of rotary motion of the gas is too feeble to be efficient.

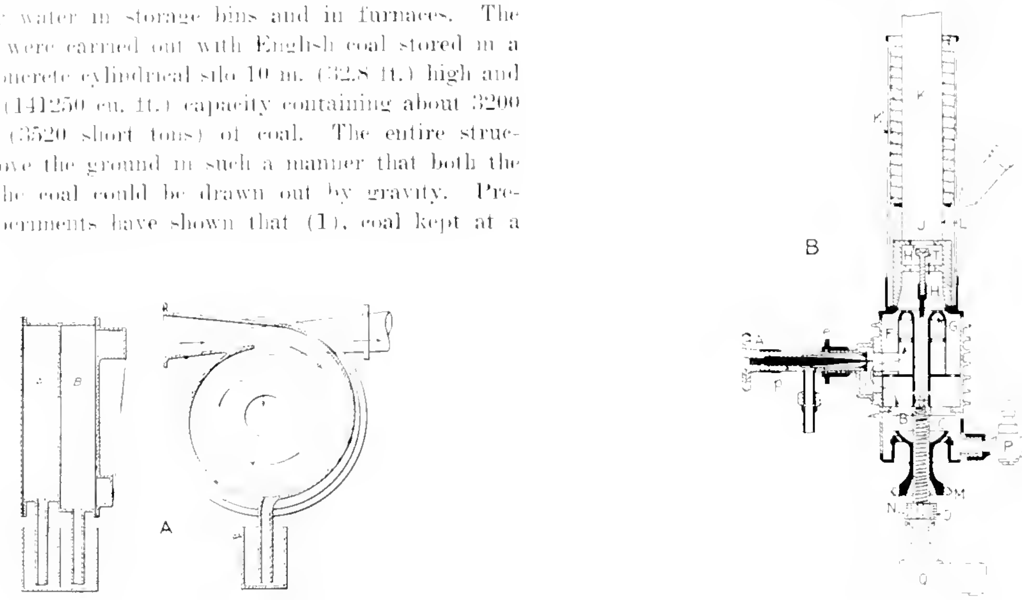

Fig. 2 A Centrifugal Tar Separator, B Comburimeter

A. Guillet in a paper on *Purification*, investigates a curious anomaly in the purification of gas by successfully passing it through three purifiers. It appears then that the gas which has not been completely purified in the second stage does not materially change its composition while passing through the third stage. This phenomenon can be explained by admitting that there is a certain ratio between the quantities of hydrocyanic acid and hydrogen sulphide in the gas at which hydrogen sulphide does not any more convert oxide of iron into a sulphur compound. Hydrocyanic acid may in fact decompose iron sulphide and set at liberty the hydrogen sulphide present. Therefore, it is quite admissible to believe that in the midst of a gaseous mass containing hydrocyanic acid, oxide of iron and hydrogen sulphide may be placed side by side without any chemical reaction between these two latter bodies taking place. This would explain why the gas containing small amounts of ammonia is purified easier than gas previously well washed. Very often hydrocyanic acid and hydrogen sulphide are absorbed together, but at a velocity which varies in accordance with external conditions. If two per cent of air be present, the hydrogen sulphide is absorbed first, in

the first stage of the purifier, and the hydrocyanic acid next, in the second stage. The author comes therefore to the conclusion that if a plant washes out the hydrocyanic acid by the wet method in a preliminary manner, the use of purifiers in three successive stages is an error, and it is more sensible to group the purifiers so as to have only two passages of approximately equal surfaces. He recommends also not to change the body of the first stage until a sulphurization is started in the second stage. The excess of oxygen in the gas after passing the first stage charged with fresh material is sufficient to regenerate the second stage, the service of which may be prolonged therefore by several years. In the discussion which followed Mallet stated that when the gas comes out unclean from the third stage, that means that the hydrogen sulphide and the hydrocyanic acid therein are in a state of equilibrium which does not permit purification at the usual velocities of from two to four mm. (0.078 to 0.157 in.) per second.

In the next paper, Grebel and Velter give an account of comburimetric tests and a description of the comburimeter designed by Velter. The comburimeter is an apparatus used for determining the quantity of air necessary for the perfect combustion of a gas. The essential parts of the comburimeter shown in Fig. B are as follows: The entrance of the gas at A is regulated by the needle p which closes more or less the orifice of the injector i. Another device connected with the injector permits to regulate the admission of primary air to the burner. In moving forward and back, the screw e carries with it the disk d of the injector (not shown on the drawing), and throttles at d more or less the entrance of the portion of the total air which, as primary air, is admitted to the burner along the path shown by the arrow. The next essential member is the air admission chamber B, which may be closed air-tight by the valve C. The movements of this valve are regulated by the indexed screw N, moving in front of a graduated drum O. As a rule, the air necessary for the working of the comburimeter is brought in by the draft of the chimney K across the throttled annular orifice between the valve C and its seat, but cock P located on the side permits the admission of a certain amount of measured air into the chamber B, even when the valve C is closed entirely. The next essential element is the annular burner G. A part of the air admitted into the chamber B mixes at d with the gas coming from the injector i, while the other part of the total air is distributed in the central space and in the peripheral chamber F. The fourth essential element of the apparatus is constituted by the combustion chamber H and the control chamber H' lined with asbestos and separated by a fire-clay diaphragm provided with a calibrated opening I. Both of them end in an identical diaphragm J. In the chamber H' is located the central support C, the purpose of which is to carry a cupelling crucible made of fire-clay for absorbing the oxide of lead during the tests; it contains a control piece of lead. A chimney of blackened copper fitted to the combustion chamber and consisting of a central tube K, with a spy window L, the bottom of which is enclosed in a crystal cylinder jacket K', finishes the apparatus.

In order to determine whether the quantity of air admitted into the apparatus does or does not produce perfect combustion, it is sufficient to observe the surface of the little lead bath through the spy window L. In a reducing atmosphere, the bath appears darker than the cupel. It reflects mirror-like on the walls of the furnace. In slightly oxidizing atmosphere, the surface which darkens right away, is covered by tongues of colored oxides, running in all directions; when the ratio of gas to air is within close limits, that is in the neighborhood of perfect combustion, the appearance of the surface of the bath frequently passes from one state to another. As a criterion of neutrality of combustion must be taken the tendency of the litharge tongues to disappear and not to appear. From experiments made by Bertin, it appears that the sensibility of the comburimeter is perfect and the slightest variation in the proportions of the air causes the appearance or disappearance of the colored tongues on the surface of the bath. In fact, the lack of oxygen is more rapidly indicated by the disappearance of litharge coloring on the surface of the lead bath than by the carbonmonoxide reaction over the iodic acid. This apparatus permits also to determine the relative comburivority of a gas by operating with a constant opening of the air valve C. A further advantage of this apparatus is that it permits the control of manufacture of the most different gases, even such as do not produce any lighting effects, the latter not being possible with such indicators as those of Lowe and Methwen.

Bigeard presented a paper on the causes of *internal attacks on cast iron piping*. He mentioned that at Angers, small diameter cast iron pipes have been obstructed by spongy brittle deposits containing up to 40 per cent of iron, sulphur and silica. The interesting fact is that the large proportions of sulphur and silica, such as determined by analysis, in the deposits do not correspond to the small proportions of those bodies in cast iron. In the discussion the opinion was expressed that the sulphur and hydrocyanic acid, also found there, may be due to incomplete cleaning of the pipes.

The Meter Company exhibited a *device for insuring the safety of gas meters in night time*. Instead of closing the main cock, the consumer may before going to bed turn this device in such a manner as to permit the flow of only a limited quantity of gas, sufficient for any purpose of lighting during the night time, but too small to cause any accident in case of a leak. Further, a safety valve prevents the danger of excessive leaks due to forgetfulness in closing the main cock after the meter has been put into normal service and acts automatically in case of a leak in the internal piping.

Masse explains very clearly the principle of establishing a *rule of calculation of gas conduits*. As a rule, use is made of the Aubuisson formula

$$h = K\frac{Q^2L}{D^5}$$

where h denotes loss of head in mm. of water, Q output in cu. m. per hour, L, length of conduit in meters, D, its diameter in centimeters, k a coefficient which varies with various investigators (Monnier makes k = 0.84). After numerous experiments on cast iron conduits, Aubéry has adopted the following formula:

$$h = 1.625\frac{Q^{1.85}\,L}{D^{4.92}}$$

corresponding to a density of gas equal to 0.44. This rule permits in general the solution of problems relating to the transportation of gas through a conduit of any length. In the discussion which followed, Grebel called attention to the fact that the formula of Aubéry is close to that of Monnier

and Blaess where the output is a function to [illegible] (p_2 exit pressure, p_1 entrance pressure) and not the more modern formulæ of Unwin and the Chicago Gas Companies where the output is a function of $p_1^2 - p_2^2$. On the other hand, however, this formula could be made to show an agreement with the results of the experiments made by the French Suburban Gas Company with the formulæ where the loss of head $p_1 - p_2$ is a function of the output Q raised to the 0.85 power while in all the formulæ, ancient and modern, the second power is adhered to in accordance with the theory of flow of fluids in pipes.

Hydraulics

Hydroelectric Installation in Kabylia (*Installation hydro-électrique en Kabylie*, L. Neu. *Mémoires de la Société des Ingénieurs Civils de France*, ser. 7, vol. 67, no. 5, p. 597, May 1914. 11 pp., 8 figs. *d*). The article describes a hydroelectric installation in Kabylia, Africa. The installation uses a double type Francis water wheel provided with a Minetti speed regulator with a servo-motor operated by oil under pressure. Fig. 3A and B show the construction of this regulator. Its essential parts are the piston K moving in a cylinder C, the two high pressure rotary pumps P_1 and P_2, distributing double seat valve V and fly-ball governor T. Each of the ends of the cylinder communicates on one hand with the delivery piping of one of the pumps and on the other hand with a discharge passage A_1 or A_2 opening into the reservoir R. When the engine runs at a normal speed, the valve V which controls the openings A_1 and A_2 is in its middle position and therefore leaves open equal amounts of cross section of the two passages, so that the oil carried into the cylinder can return back to the reservoir without exerting any pressure on the piston. But as soon as the speed of the engine begins to decrease or increase as compared with normal speed, the valve V, in consequence of a variation of the work of resistance, is shifted under the influence of the centrifugal governor and comes to cover up one of the discharge passages. Then the oil delivered by the pump on the closed side, not being able to return to the reservoir, forces the piston to move in a corresponding direction, this motion being transmitted later on to the gates of the turbine by means of the lever H connected with the governor shaft W.

The rotary pumps can deliver a working pressure up to 10 atmospheres. The distributing valve is perfectly balanced; the levers a, b, and c provide for its return to its middle position, and a very small displacement of the distributing valve is sufficient to start immediately the servo-motor. All changes in speed resulting from a retardation of its functioning are suppressed owing to the incompressibility of the oil which is used to insure the instantaneous action of the speed regulation. The hydraulic pressure acting on the servo-motor does not act all the time, but goes into action only at the very instant when the speed regulation has to take place, its value being proportional to the resistance offered by the governing organs of the turbine water supply system. If it is desired to stop the action of the governor while in operation without at the same time stopping the pumps, the valve is lifted and both ends of the cylinder C placed into communication with one another. This valve also acts as a safety valve by limiting the maximum pressure in the apparatus to that necessary for operating the gates on the turbine plant, and comes into action in case of accidental ruptures which may occur when a hard body gets into the turbine regulation device. The time required for closing is about three seconds, the regulation of the turbine being practically instantaneous.

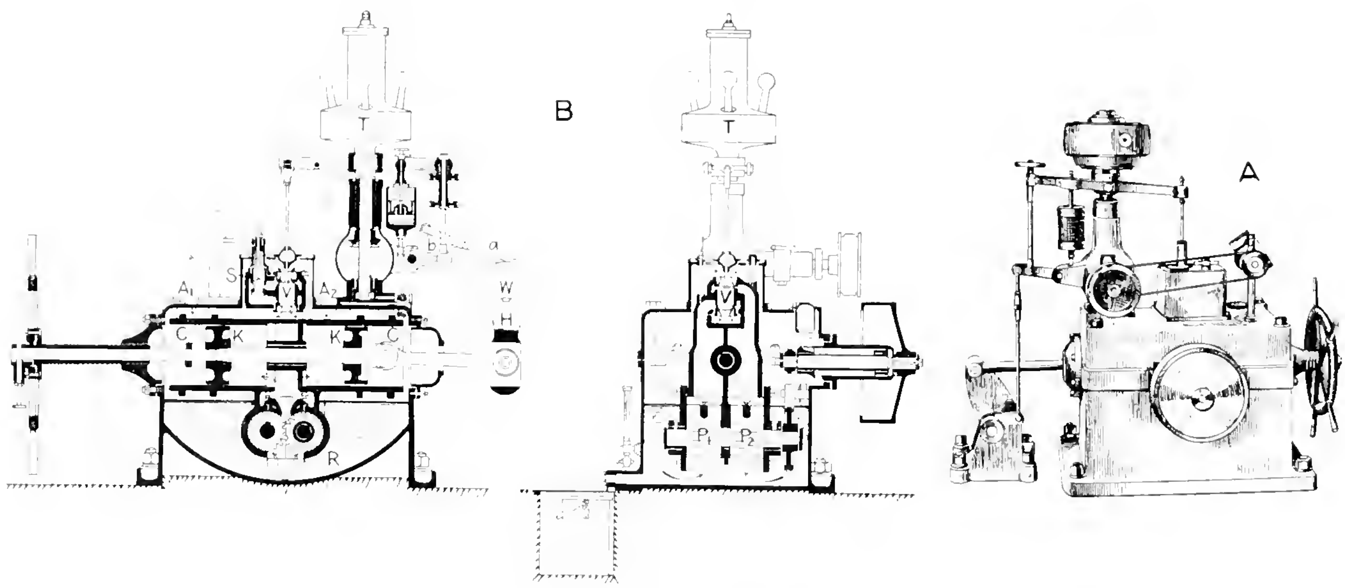

Fig. 3 Minetti Hydraulic Turbine Speed Regulator

Internal-Combustion Engineering

Modern Cooling Devices for Use on Internal Combustion Engines (*Neuere Kühleinrichtungen für Verbrennungsmotoren*. Dr. F. Georgius. *Dinglers polytechnisches Journal*, vol. 329, no. 29, p. 453, July 18, 1914. 3 pp., 8 figs. *d*). The article describes modern devices for cooling internal combustion engines. While the cooling forms a very important part in the operation of internal combustion engines, one of the most dangerous occurrences as far as the life of the cylinders is concerned is the rapid variation in temperature and stresses produced thereby, due to the sudden flow of cooling water after it has been interrupted for

a time through some cause. For a long time, water was the main cooling agent, but lately the Augsburg-Nurenburg Machine Company has turned to the use of oil with which very good results have been obtained in the engines supplied to the Dutch warships. The oil in this case runs in a closed circuit and is cooled by a flow of water. It is pumped under a pressure of from 2.5 to 5 atmospheres, and is used both for cooling and in some instances for lubricating, as for example in main bearings, driving-rod and crank shaft. The present article describes the cooling vided with a non-return valve k; during the suction stroke this valve opens; during the pressure stroke the water is compressed partly through the piping d and partly by means of the piston rod b. As a result no separate drive for the cooling water circulation pump is required. This arrangement, however, can be used only in the case of engines which have space available for the pump over the cylinder cover.

For engines in which the fuel injection nozzles are located on the cylinder cover, it is advisable to have a special sys-

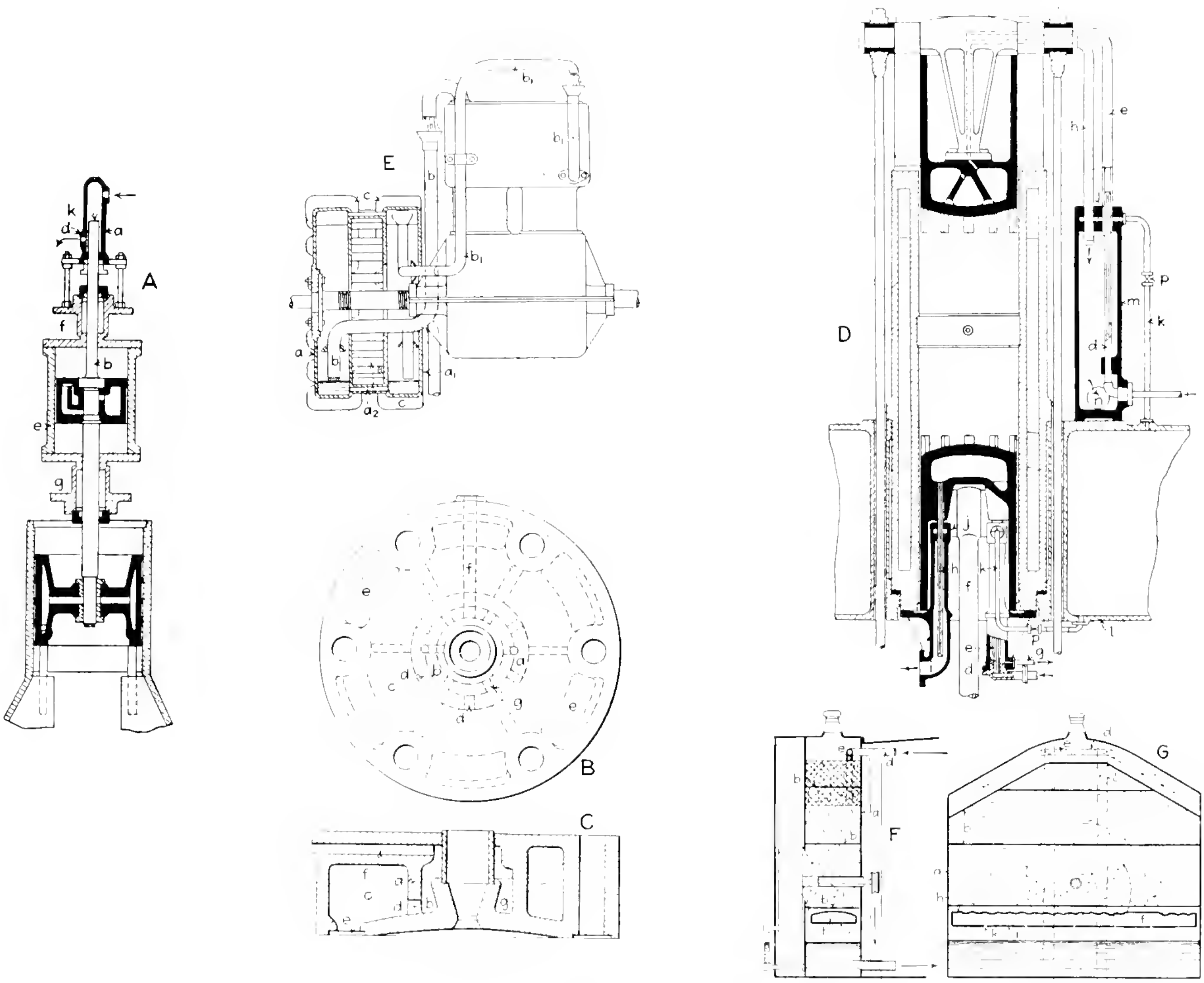

Fig. 4 Cooling Devices for Use on Internal Combustion Engines

devices placed on the market by Krupp, the German General Electric Company, Gondard & Mennesson, Längerer & Reich, Daimler Motor Company, Kreul & Hesselman. An interesting solution of the problem of cooling is presented by Kreul. He avoids the use of a special water service pump by using a pump placed on the cylinder cover; in this pump the extension of the piston rod works as a piston as shown in Fig. 4A. The pump a is placed over the cylinder cover f and the piston rod b acts as the piston of this pump. The liquid handled by the pump is conducted by the pressure pipe d on to the cylinder e and the cylinder covers f and g. The water circulation takes place through the piston rod b which is for this purpose pro-

tem of cooling the nozzle passage in the cover. To do this, Hesselman (Figs. B and C) provides for a special water chamber around the fuel passage in the cover separate from the general water chamber. The opening in the cover is divided by the wall a into two spaces b and c, connected with one another by the passage d. The outer chamber is connected by the opening e with the water jacket of the cylinder while the water runs away through the passage f. Radial grooves g are used in order to prevent the water coming in through d from flowing through the inner space b in a peripheral direction and to force the water to run along the walls of the nozzle passages.

When the cooling liquid is not brought in through the

piston rods, special pipes attached to the piston and dipping into a fixed tank are used. In order to provide for a good packing of these pipes in the tank walls, the German General Electric Company uses the gaseous pressure medium flowing in a direction opposite to that of the cooling medium. For example, if an internal combustion engine with opposed pistons such as is shown in Fig. D is used, than the cooling medium (in this case, water) is brought on to the lower piston by a pipe *d* and another pipe *e* fixed to the piston and having a slight play between it and *d*. The liquid which leaks between the pipes *d* and *e* is caught in the tank *f* through the upper wall of which the pipe *e*, provided with mechanical packing, passes through. The leakage is then conducted away by the pipe *g*. The cooling water, at a higher temperature, after it has done its work, is taken away from the piston through pipe *h* and tank *i*. The upper ends of the tanks *f* and *i*, permitting a passage of the pipes *e* and *h*, are provided with chambers *j* which are connected with the scavenging air tank *l* by the pipe *k*. The air compressed to a pressure above atmospheric, reaches from the tank *l* into the chamber *j* and from there through the pipe packing in part directly into the atmosphere but mainly into the tanks *f* and *i*; while passing into this latter it forces the liquid back into them and thus prevents the lubricating oil from getting into the driving parts as well as mixing with the cooling water. The air itself is later on allowed to escape together with the leakage of the liquid. In the case of the cooling arrangement of the upper piston which in all other respects is designed in a similar manner to that of the lower piston, the admission pipe *d* and return flow pipe *h* open into the same tank *m*, the connection between the pressure chamber *j* and scavenging tank *l* occuring through the pipe *k*. As a means of packing, may be used a part of the air compressed either in the working cylinder or in the pumps. The pressure of the air used as a packing medium may be regulated by the valve *p* and since the cooling water is certain not to mix with the lubricating oil, it may be immediately used again after it has been cooled to its initial temperature. Another arrangement used by the same concern in order to prevent a leakage of the cooling medium through a movable pipe connection consists in driving the cooling medium through the piston and pipe connections not under pressure but under suction. In all of these cooling chambers and pipes the pressure is below atmospheric, the flow of the liquid being prevented thereby. For this purpose any pump may be used, and the pressure piping can open into the suction chamber.

Among other types may be used also cooling arrangements consisting of a rotating tank and stationary pipe system. By the rotation of the tank, owing to centrifugal force acting on the liquid, a pressure and suction are produced at the openings of the admission and exit pipes respectively. A cooler designed on this principle by Goudard and Mennesson is shown in Fig. E. In this case two drums a and a_1 located side by side on the same axis and interconnected by a bundle of pipes a_2 are used as cooling chambers. A stationary system of piping is connected with this rotating drum by the central opening in such a manner that the liquid is admitted into one of the drums and flows out again through the other. The pipe ends b and b_1 have a free opening into the respective drums without there being any need for packing. The rotation of the drums driven with a considerable velocity by the engine produces without any further appliances a circulation of the cooling medium through the joints of the engine. In order to prevent a syphonic action which might take place while the engine is stationary, the system of piping is interrupted both at the admission and exit ends on the cooling jacket. The cooling drums are sometimes made of aluminum. Owing to the fact that the two drums are connected with one another by the system of piping a_2, freely surrounded by outside air, a good cooling of the cooling water of circulation is produced. If necessary, fins *c* may be added to intensify the cooling action.

The arrangement permitting a rapid cooling of the circulating water after coming from the water jacket has the further advantage that the supply of cooling water may be maintained as low as possible. This circumstance is of particular importance in the case of engines used on vehicles of various kinds. In order to achieve this, Längerer and Reich make the circulating water to come into direct contact with air (Fig. F and G). A chamber *a* is divided into two by a sieve *b*. The space is filled with a filter mass. The water coming from the engine jacket arrives through the pipe *d* and thus reaches the atomization pipe *e* which distributes it over the entire cross-section of the cooler. In the lower chamber of the cooler an air atomizer *f* is built-in, the upper surface of which is arched laterally and has a wave-shaped appearance in the longitudinal direction, there being provided at the crests of the waves slots *h*, while in the lower flat surface *i* there are a number of openings *k*. The water entering through the pipe *e* flows through the sieve and the filtering mass, and later on goes again to the engine jacket from the lower collecting tank. The air to the atomizer *f* is supplied by a fan driven by the engine or some similar appliance. It enters into the cooler uniformly distributed through the longitudinal slots *h* and flows counter current to the water coming from the engine jacket, this ensuring an intimate contact between the cooling air and the water. The sieves serve to prevent the filter mass from packing too tight. The well known system of cooling used on the motor cars of the Daimler Company is also described in the article.

STEEL CYLINDERS (*Stahlzylinder*, F. Klinkenberg. *Der Motorwagen*, vol. 17, no. 19, p. 451, July 10, 1914. 3 pp., 1 fig. *d*). While the manufacture of cast iron cylinders for motor traction has reached a high stage of perfection involving the use of specially adapted high grade cast iron, determined efforts are made in Germany to promote the use of steel cylinders, especially where the lower weight of the latter is a factor of importance. In Germany, a concern called the Steel Motor Company Ernst Jaenisch & Co., in Berlin, has of late been making a specialty of the manufacture of steel cylinders for automobile engines. The manufacture has been carried on in a well regulated manner of mass production, with specially designed machine tools and production to close dimensions. The en-bloc type is mainly produced. Fig. 5 shows a four cylinder engine cast en-bloc 80 mm. (3.14 in.) bore and 130 mm. (5.118 in.) stroke for a motor rated at 10 h.p. under the German motor tax rules. The general arrangement of the valves and suction and exhaust connections does not differ from normal construction, but one can see the extreme care taken in the execution of the passages, valve chambers and cooling water jackets.

The walls, contrary to what is done in the case of cast iron cylinders, are made extremely thin and in some places, for example the cover and cooling water jackets, are approximately not more than thin sheet steel; even the valve chamber plugs are nothing but light steel pieces. The suction passages are, in accordance with the modern practice, placed inside the cylinder block while exhaust piping is located on the outside and held by means of thin flanges. The purpose of locating the exhaust piping on the outside is to give a chance for better cooling since when, experimentally, the piping was placed inside the cylinder block, it resulted in an irregular and one-sided heating of the block and extreme stresses in the material. The bend in the exhaust pipe is also very light and consists of thin steel piping 0.059 to 0.078 in. thick.

The cylinders are made of an excellent special grade of steel and machined throughout. They are adapted to any compression pressure which may arise and can withstand for a long time all possible stresses, which is not the case with the ordinary steel cylinder with the *head* simply welded in. The valve guide bushings are made of a special steel casting and either set in or pressed in in the corresponding steel sleeves of the block body without requiring any further means of fastening. A special process not described in the article is used for joining the cylinder with the water jackets and the latter with the cover (from other information it would appear, autogenous welding is used for this purpose). The machining of the inside of the cylinder is done in a very simple manner, the cylinder being bored and then simply reamed with a reamer of suitable dimensions.

There might be some trouble from the difference between the cast iron piston rings and the steel cylinder; it is, however, known that the surface of the cast iron cylinder hardens within a short time so that the conditions of working in the steel and cast iron cylinders are about the same and no trouble worth speaking of has been observed hitherto in the operation of steel cylinders in this respect. With respect to cooling water circulation, it is essential that the cooling water after its entrance into the cylinder block be admitted directly and automatically under the hot exhaust valve chamber before it is allowed to rise further; for this purpose, special passages are provided which can be seen on the figure of the block looking from above under the cross-section of the suction pipe. The design shown in the drawing involves cooling by means of a pump, but there is also a special construction with automatic cooling by the thermo-syphon system.

Three main advantages are claimed for the steel cylinder of this type of construction: In the first place, low weight, approximately one third of that of the cylinder of equal output in cast iron, which is of importance for automobile construction; in the second place, the uniformity in the distribution of material and possibility of using thin walls for the cylinder water jacket, exhaust piping and so on, permit very advantageous effects in the introduction and dispersal of heat. The thermal efficiency of an engine and its output, especially when operated at a constant forced load, depend to a very high degree on the transmission of heat to the cooling water and the dispersal of heat to the atmosphere, and the advantages presented in this respect by the use of steel permit higher compression pressures than would be the case in similar cast iron cylinders. The third important advantage is the possibility of using the exact shapes and dimensions inside the cylinder block which are required by the designer of the engine, without having to count with the eventualities of casting as is the case in cast iron cylinders. The use of steel permits the employ of any means of construction and any variation of cross-section of passages. The main disadvantage of this type of construction is its higher price; this, however, depends materially on the extent and method of manufacture and may not count so much in view of the important advantages lying on the other side.

Pumps

Concerning the Calculation of Water-Jet Air Pumps (*Zur Berechnung der Wasserstrahl-Luftpumpen*, Professor C. Pfleiderer. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 24, p. 965, June 13, 1914, and no. 25, p. 1011, June 20, 1914, 12 pp., 16 figs. *teA*). The article presents methods of calculation of so-called water-jet pumps; that is, de-

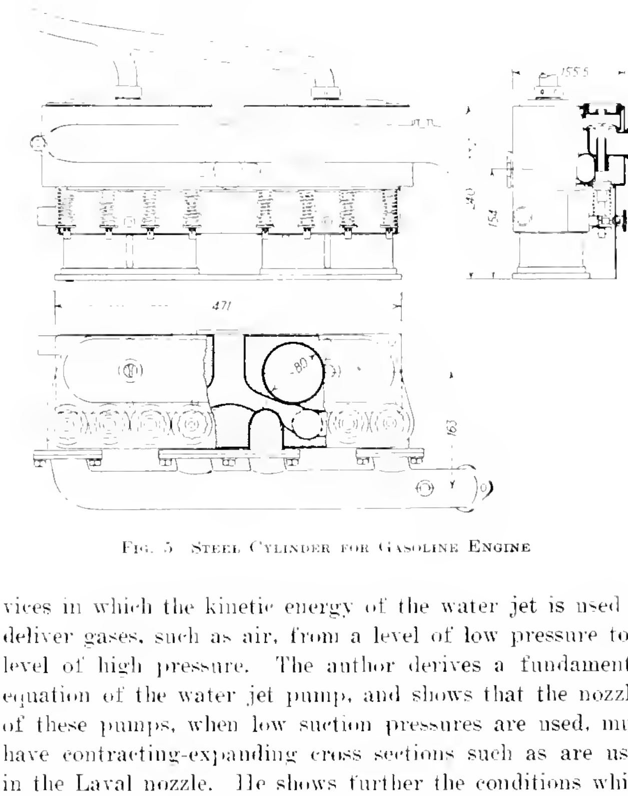

Fig. 5 Steel Cylinder for Gasoline Engine

vices in which the kinetic energy of the water jet is used to deliver gases, such as air, from a level of low pressure to a level of high pressure. The author derives a fundamental equation of the water jet pump, and shows that the nozzles of these pumps, when low suction pressures are used, must have contracting-expanding cross sections such as are used in the Laval nozzle. He shows further the conditions which lead to an oscillation in the air vacuum and cause interruptions in the operation of the pump. He develops a process which gives means to prevent the interruptions in the flow of water and undesirable variations in its velocity. He determines further the efficiencies of water jet pumps and proves that such a pump works the more efficiently, the higher the *velocity* of the water and the smaller the *amounts* of water, on condition, however, that the amount of water is still sufficiently large to handle the respective amount of air to be delivered. He gives several examples showing processes used in the calculation of jet pumps and distinguishes between nozzles with a straight central line and annular nozzles and shows that in the case of the latter the circular motion of the water requires the use of special equations. He proves further that water jet pumps actually behave like piston pumps with an infinitely small clearance, in so far as they have a tendency to maintain the amount of

a[illegible] take[illegible] constant, notwithstanding the variations in the suction pressure.

The Spiral Chain Pump (*Die Spiraldrahtpumpe, Kraft und Betrieb*, vol. 3, no. 6, p. 89, June 27, 1914, 1 p., 2 figs. *e*). In *The Journal* August 1912, pages 1252 and 1253, was described and illustrated a new device for raising liquids consisting of a closely wound spiral with the chain inside designed by the French engineer Bessonet Favre. At that time, no precise data of tests was available. The chain pump of this design presents certain advantages in being able to handle equally well cold or warm, clean or dirty water, and because it has no valves, stuffing-boxes or packing, it must be very simple in operation and cheap to install. The following data of tests may be of interest. To convert the data to American units, it is necessary to multiply the volume of water given in cubic meters by 35.314 which will give cu. ft. and the h.p. by [illegible] which is the conversion constant to change from continental horse power to the corresponding American unit.

TABLE 1 DATA AND TESTS OF A BESSONET-FAVRE CHAIN PUMP

Diameter of Chain, mm	Number of Wire	Output and Power Consumption for a Delivery Head of 10 m.	20 m.	30 m.	40 m.	50 m.	60 m.	
24	1	3900	3650	3350	....	....	....	cbm. per hr
		0.25	0.4	0.5	....	....	....	h.p
27	1	4500	4350	4150	3900	3600	3250	cbm. per hr.
		0.3	0.45	0.6	0.7	0.8	1.0	h.p
32	1	5500	5300	5100	4900	4700	4500	cbm. per hr.
		0.35	0.55	0.7	0.8	1.0	1.2	h.p.
40	2	10000	9800	9575	9325	9050	8750	cbm. per hr
		0.6	1.0	1.2	1.8	1.7	2.1	h.p.
55	2	15000	14600	14200	13800	13400	13000	cbm. per hr.
		0.9	1.5	1.7	2.2	2.6	3.0	h.p.
62	3	20000	19500	19000	18500	18000	17500	cbm. per hr.
		1.1	2.0	2.3	2.9	3.5	4.1	h.p.
80	3	30000	29500	29000	28500	28000	27500	cbm. per hr.
		1.75	2.9	3.5	4.5	5.4	6.3	h.p.

Steam Engineering

Friction (Tesla) Turbines (*Les turbines à frottement ou Tesla*, Professor E. Mérigeault. *Revue de Méchaniques*, vol. 34, no. 6, p. 538, June 30, 1914. 7 pp., 6 figs. *t*). The article gives an attempt at construction of the theory of the Tesla turbine as well as a discussion of its theoretical efficiency. As regards the possible improvement of this type of turbine, the author states that it lies in the direction of decreasing as far as possible all internal friction which causes loss of efficiency, and recommends the following methods. First, to use disks, the internal and external radii of which are close to one another so that a molecule of water may escape after having made a single turn. At any instant, therefore, there will be present only one spiral of current and this spiral will approach in its shape an arc of a circle. Second, to add to the disks, spiral transverse partitions directing the current which are so close to one another that they will be like a streamline passing in a channel between two successive partitions. In this way the current of fluid will exert on the entire periphery a friction against metallic walls combined with a movable wheel. Here again each spiral will come very close to an arc of a circle.

Evaporation Test of a Steam Boiler Equipped with Improved Wefer Gas Firing (*Verdampfungsversuch an einem mit der verbesserten Wefer-Gasfeuerung ausgerüsteten Dampfkessel*, A. Butow and O. Dobbelstein, *Glückauf*, vol. 50, no. 26, p. 1030, June 27, 1914, 2 pp., 1 fig. *de*). This article is practically a continuation of the article on the same subject and by the same author, abstracted in *The Journal*, July 1912, page 1118, where previous tests of the same system of firing on a double boiler have been reported. Since then the Wefer system of firing has been improved and reconstructed in the form shown in Fig. 6. The coke-oven gas passes from the gas chamber *a* through 40 pipes *b* into boiler openings *c* of the graphite body *d* where it mixes with the air entering through the annular sliding valve *e* and burns up in the fire room *f*. The entire burner is set in a cylindrical extension *g* of the firebox frame. The firebox is directly connected with the external atmosphere by a centrally located pipe 200 mm. (7.87 in.) inside diameter; in the former design this pipe was closed by the loosely lying explosion cover, which now lies over the gas chamber; the new arrangement has the advantage of providing a larger free cross-section for possible explosion shocks. In the older design, there were only 25 gas admission pipes which formed a closed central bundle; the present arrangement makes possible a better subdivision of the gas, and mixing between the gas and air. The burner openings have been shifted to the end of the fire tube by

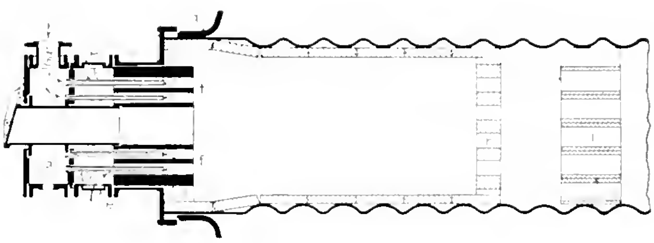

Fig. 6 Improved Wefer Gas Firing

building the burner into the extension *g* and by this means the fire tube has been made available for useful heating throughout its entire length. Finally, in order to provide as large a contact space as possible between the gas mixture and the incandescent pieces of fire clay and to achieve thereby a complete combustion, a layer of pipe-pieces *i* has been placed behind the fire brick grating *h*. The arrangement of the plant as compared with that reported previously has been changed somewhat through the installation of a gas holder of 40,000 cbm. (1,412,580 cu. ft.) capacity which permits to maintain the gas pressure quite steady, contrary to what was the case in the former tests. The benzol plant has been enlarged so that the gas is now practically free from benzol and therefore of a somewhat lower heating value. The tests were made on April 26, 1914, with a double flue boiler of 115.4 qm. (1135 sq. ft) heating surface. Its results are shown in table 2. A comparison of these data with the data obtained in the previous tests shows that notwithstanding the increase in the boiler output from 21.83 to 28.38 kg. per hr., the total efficiency of the plant went up to 84.6 per cent or increased by 5.4 per cent. It must, however, be borne in mind that in the former tests the heating value of the gas, as obtained by analysis, has not been referred to the temperature of deter-

mination. If this fact be taken into consideration and the difference in heating value of 105 W E (189 B.t.u. per lb.) be introduced into the calculation, the rise in boiler efficiency will be reduced to 3.4 per cent, which still shows that the change in construction has improved the Wefer boiler.

TABLE 2 DATA OF TESTS OF AN IMPROVED WEFER GAS FIRING INSTALLATION

Duration of test		8 hr.
Steam pressure. . .		12 0 atmospheres gage
Feedwater consumption, kg lb		26608 58537
Steam generation:		
from water at 0 deg. cent. (32 deg. fahr.) to steam at 100 deg. cent. (212 deg. fahr.) and 637 WE (1146 B t u.) kg lb.. . . .		26204 57648
Steam generation per hr., kg lb		3275 5 7206
Steam temperature at superheater, deg cent. fahr.. . .		297 0 566 6
Total gas, volume, cbm cu. ft..		5633 198,924
Gas volume per hr., cbm cu. ft..		704 1 24864
Pressure, gage, in the gas piping, mm water.		148 0
Gas temperature, deg. cent., fahr.		35 0 95
Barometer, mm. mercury ...		755 3
Composition of gas, per cent:		
CO_2.	1 6	
O	1 8	
CO	4 6	
H.	52 2	
CH_4.	28 8	
Heavy hydrocarbons	1 6	
N ..	9 4	
Average composition of flue gases, per cent:		
CO_2....	8 3	
O	3 24	
CO. .		
Excess of air	1 6 times	
Temperature in the fire chamber, deg. cent., fahr.........		1425 2597
Average temperature of flue gases in the flue, deg. cent., fahr. ...		225 437
Results:		
Output of steam at 637 WE (1146 B.t.u.) per 1 cbm of gas kg lb. per cu. ft. of gas.	4 65 0 288	
Output per 1 qm of heating surface, per hr. kg lb. per sq. ft...		28 38 2 6
Saturated steam, per cent.....	77 6	
Superheated steam, per cent.........	7 0	
Loss through conduction and radiation, per cent..................	15.4	
Total, per cent.........	100	

STEAM EJECTO-CONDENSERS (*Les éjecto-condenseurs à vapeur*, Professor Aime Witz. *La Technique moderne*, vol. 9, no. 1, p. 1, July 1, 1914, 8 pp., 14 fig. *dee*). The article describes various types of steam ejecto-condensers mainly for use with steam turbines such as the Leblanc, Parsons, Körting and Delaporte apparatus. The main interest of the article lies in the information given of tests of the latter type made by the author at the plant of the Breguet Company. The apparatus itself known under the name of ejectair has been previously described in The Journal, July 1913, p. 1183. The article describes the experimental installation used for these tests. In the first series of tests were determined the characteristic curves of the operation of the ejectair under different temperatures of the water at exit from the main condenser and at admission into the small auxiliary condenser placed between the two ejectors. The name of characteristic curve was given to the curve plotted with the fall of vacuum in centimeters of mercury as ordinates, and the admission of supplementary air in kilograms per hour as abscissæ. These curves should be plotted within the regions of approximately half load and full load, with and without cooling; the fall of vacuum would be expressed with regard to the theoretical vacuum as determined by the difference between the normal barometric pressure of 760 mm. and the vapor tension corresponding to the temperature of water in the condenser in millimeters of mercury. The comparison between the characteristics at half load and at full load should have brought out the well known theorem that the fall of vacuum referred to

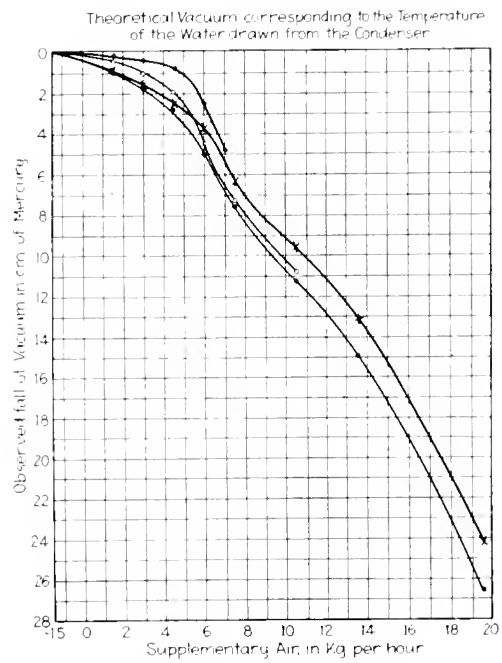

FIG. 7 CHARACTERISTIC CURVES OF THE DELAPORTE EJECTAIR

the theoretical vacuum corresponding to a given temperature of water flowing out from the condenser, depends only on the amount of air admission and not on the quantity of steam admitted to the condenser. This theorem assumes that the condenser is perfect. Its more or less approximate verification ought to give a basis for estimating the degree of perfection of the apparatus and its practical value. On the other hand, it gives a criterion of the precision of the results observed. The comparison between the curves obtained with and without cooling from atop brought out another fact, namely, that in carrying the curves down to the origin of the co-ordinates by means of an extrapolation, which, however, should not be excessive, a point is found where the action of the cooler is zero. At this point there is no more air in the condenser, and the abscissa of this point gives consequently the weight of air brought by the water of injection. At this point also, the theoretical vacuum is obtained, and its position gives a new point of control for the observations made. With the characteristics having been plotted and verified in this manner, the values for the total air admission can be deduced in grams per sec-

ond and per horsepower, and the percentage of the vacuum actually obtained can be determined as a function of the theoretical vacuum for various temperatures of water in the condenser. These new results give very interesting graphical curves obtained by using as ordinates the weight of air extricated per second per h.p.-hr., and as abscissæ the vacuums in per cent of the theoretical vacuum; thus, by taking into consideration the possible utilization of the calories expended in the apparatus on feeding it with live steam, new curves were obtained of great value. The author gives in considerable detail the results obtained in his experiment both in tabular form and in curves. On account of lack of space, we shall reproduce here only the most important curves. In figure 7, curves 1, 2 and 3 are characteristic curves. One notices that curve 4 of the vacuum taken with water coming from the condenser at about 41 deg. cent. (105.8 deg. fahr. and for the purpose of cooling water

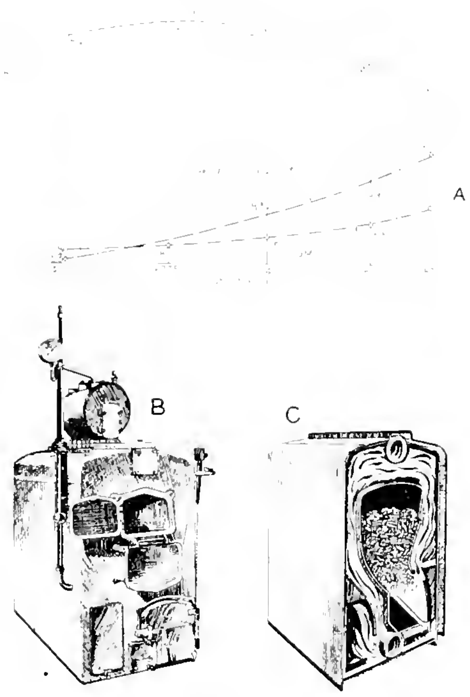

FIG. 8 LOLLAR BOILER

being used at about 18.5 deg. cent. (65.3 deg. fahr.) remains for a long time above curve 3 which corresponds to the same temperature of cooling water and a temperature of 40.5 deg. cent. (104.9 deg. fahr.) in the main condenser. For an admission of air of 4.5 kg. (9.9 lb. per hr.), the variation is about 18.5 mm. The two curves intersect at the origin at a point which corresponds strictly to the theoretical vacuum for the temperature of the water taken from the condenser which is an important proof of the precision of the results obtained. This point of intersection has for abscissa the value of 1.5. The author comes to the conclusion that this expresses the admission of supplementary air due to the water of injection in the condenser and perhaps also due to leakage of some other sort. In order, therefore, to find the total air admission, the values of the abscissæ will have to be increased by 1.5 kg. or 3.3 lb. The author also confirms the previously known fact that the admission of the air in the upper part of the injector produces a less depressing effect than when the air is admitted directly into the condenser.

LOLLAR BOILERS AND RADIATORS (*Lollar-Kessel und Radiatoren*, Pradel. *Zeits. fur Beleuchtungswesen, Heizungs-Lüftungs-Technik*, vol. 20, no. 17. *de*). The author describes the so-called Lollar boilers and radiators, a type of sectional boilers used to a considerable extent in Germany. While coke is the natural fuel for this type of boilers, boilers have been also built for use with brown coal and lignite briquettes. Fig. 8A shows the efficiency loss through flue gases and draft in the case of five different loads on the boiler. Figs. B and C show the construction of such a boiler designed to use lignite briquettes and generate low pressure steam. Fig. B shows the boiler in actual construction and Fig. C with the front section removed. The main advantage of the Lollar briquette boiler consists in the fact that the firing is done on the half gasification principle, the gasification of the fuel taking place on an inclined grate which through constant shaking is automatically kept free from clogging with ashes. The auxiliary air is preheated to a very high degree before it reaches the combustion chamber and on this account causes the complete combustion of the gases in the combustion lying above the grate. This combustion chamber is separated from the boiler by plates of refractory material. The admission of the main and auxiliary air of combustion occurs through a common fresh air valve operated either by hand or by a separate governor. This arrangement has the advantage that the ratio of the two kinds of air admitted remains identical at all times and for all loads, and in this way a perfect combustion without soot formation is secured under all circumstances independently of the performance of the attendance. It has been many times found that the gases developed during the combustion of lignite briquettes are apt to cause explosions when fresh air is suddenly admitted, thus endangering the boiler attendants. In order to prevent the occurrence of such explosions, the Lollar boiler is provided, as shown in Fig. B, with the screen door over which is placed the charging door proper. This latter is connected with the air valve in such a manner that when it is opened, the air valve closes; as a result the air enters in a state of fine sub-division through the yet closed screen door and such gases as may have been present in the charging chamber have time to be quietly consumed before the screen door is opened for charging the fuel.

Miscellanea

COMPARATIVE TESTS OF MINERAL LUBRICATING OILS WITH AN ADDITION OF 1.5 PER CENT OF OILDAG (*Vergleichende Untersuchungen von Mineral-Schmierölen mit 1.5 vH Zusatz von Oildag*, A. Saytzeff. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 29, p. 1174, 3½ pp., 8 figs. *ee*). The article gives a brief account of tests carried out in the Laboratory of Applied Mechanics of the St. Petersburg Polytechnic Institute in the Summer of 1913 on the use in lubrication of pure oil and oil with an addtiion of 1.5 per cent of Oildag. The oils used were the Gargoile Dynamo Oil E, and Etna Engine Oil of the Vacuum Oil Company. The tests were made in accordance with the Petroff process for the determination of the coefficient of internal friction η, and, by means of the Martens oil testing machine, for the determination of the frictional resistance W and the coefficient of friction f. The article gives the data obtained in the form of tables and curves. It was found that, as compared with pure dynamo oils, oil with an addition of

1.5 per cent Oildag at temperatures above 30 deg. cent. (86 deg. fahr.) differed but slightly from one another with respect to internal friction; it was advisable to add a little Oildag to thin oil, mainly when the bearings begin to heat; the mechanical friction of thick oils was reduced by about 7 per cent by the addition of 1.5 per cent of Oildag. In every case, the addition of one to two per cent of Oildag resulted in material reduction of the consumption of lubricating oil.

ENGINEERING SOCIETIES

ASSOCIATION OF AMERICAN STEEL MANUFACTURERS

As the publications of the Association were not available at the time of making the abstract, the present information has been taken from the *Industrial World*, vol. 48, no. 29, July 20, 1914, p. 857. The Association of American Steel Manufacturers has printed specifications as revised April 21, as follows:

Structural and boiler steel.
Concrete reinforcement bars rolled from billets.
Rail steel concrete reinforcement bars.

In structural and boiler steel, the principal changes are the narrowing of the tensile range for fire box steel from 10,000 lb. to 8,000 lb., and new tables covering the permissible variations in gage and weight of sheared plates. These tables replace tables which were adopted by the association in 1896 and which have since been widely copied into nearly all plate specifications. The present tables, giving percentages of permissible variation up and down respectively, according to different thickness and widths of plates, refer to individual plates rather than to averages. The subdivision as regards width particularly is carried out in much more detail than in the old tables.

In the specifications for concrete reinforcement, bars rolled from billets an intermediate grade of bars has been introduced, with a tensile strength of 70,000 to 85,000 lb.

In the rail steel reinforcement specification, paragraph 5 (a) reads as follows respecting tests:

One tensile and one bending test shall be made from each lot of 10 tons or less of each size of bar rolled from rails varying not more than 10 lb. per yd. in nominal weight. Should a test specimen develop flaws or should the tensile test specimen break outside the middle third of its gaged length, it may be discarded and another test specimen substituted therefor. In case a tensile specimen does not meet the specifications, an additional test may be made.

ENGINEERING ASSOCIATION OF THE SOUTH

Proceedings, vol. 25, no. 2, April, May and June 1914, Nashville

Control of Mississippi Floods, Professor W. H. Schuerman
Report of Special Committee on Nashville Smoke Ordinance, C. H. Simpson (abstracted)

Report of Special Committee on Nashville Smoke Ordinance, C. H. Simpson (24 pp., *g*). The article presents some data on the history of the Nashville smoke ordinance as well as the text of that ordinance. One of the features is that it permits dense smoke for thirty min. of the first hour in which the boiler is being fired up and twelve min. in each hour following should it be necessary to clean out or start a new fire. At the present time, Nashville has a thoroughly organized Smoke Department. Any person who violates any of the provisions of the smoke ordinance except as otherwise provided therein shall be find not less than $5.00 and not more than $25.00 for each offense.

FRANKLIN INSTITUTE

Journal, vol. 178, no. 2, August 1914, Philadelphia

Modern Research in the Metallurgy of Iron, Allerton S. Cushman
Producer Gas From Low Grade Fuels, R. H. Fernald (abstracted)
Locomotive Superheaters and Their Performance (discussion, abstract of the original article in The Journal, August 1914, p. 168)

Producer Gas From Low Grade Fuels, R. H. Fernald (20 pp., 20 figs., *de*). The article discusses the production of producer gas from low grade fuel mainly with the view of indicating the commercial conditions influencing the installation of low grade fuel producer plants. As compared with the steam plant, the producer gas installation is about twice as economical. A comparison is made between one of the most efficient steam plants in this country, the Interborough Rapid Transit Company's 59th Street Power Station in New York City, and the theoretical gas plant devised on the same scale by Mr. Stott, Superintendent of Motive Power of the same company. In the steam plant out of 970 B.t.u. put into the furnace 100 B.t.u. are realized at the bus-bars. In the gas plant in order to realize 100 B.t.u. at the bus-bars, 465 B.t.u. have to be charged into the producer. From a series of tests of a number of different Illinois coals, a comparison of the quantity of fuel for h.p-hr. required in the steam plant and in the producer gas plant at the Bureau of Mines showed that on the average the former required 2.6 times as much as the latter. The author gives detailed data of the distribution of heat in typical steam and gas plants and passes then to the description of the main types of gas producers now in use such as the suction type, the up-draft pressure type, the down-draft type and the double zone type.

INSTITUTION OF ELECTRICAL ENGINEERS

Journal, vol. 52, no. 236, June 15, 1914, London

The Bonecourt Boiler, C. D. McCourt (11 pp., 7 figs.). The article describes what is known as the Bonecourt Boiler which is a surface combustion boiler. The combustible gas and air in the proportions theoretically required for complete combustion are intimately mixed together so as to produce a homogeneous gaseous medium which is then delivered at a high speed into a bed of refractory material on the surface of which combustion takes place flamelessly. As such a mixture of gas and air is explosive, it has to be supplied to the granular bed at a speed greater than the speed at which the mixture will ignite in a backward direction. It is found that with a combustion proceeding in this way, the proximity of water cooled surfaces has no hindering effect on it and it is possible to arrange the granular bed in relation to the water space as to obtain the maximum possible proximity of the water to the heat zone. As it is more convenient to pack the interiors of the tubes with refractory granules than to surround water tubes with these granules, the multitubular type of boiler was the one to which this system has first been applied. The boiler tubes are closed at their entrance ends by fire-clay plugs having holes through which the gas mixture passes. The holes are of

such cross-section that the speed of flow of the mixture is greater than its speed of ignition. In order to cause the gas mixture to pass through the apertures in the fire-clay plugs with the required speed and to enable the products of combustion to overcome the resistance offered by the refractory packing in the boiler tubes, it is necessary to maintain a certain difference of pressure between the opposite ends of the boiler tubes. The amount of this pressure difference required will depend upon the rate of evaporation. In general, the pressure difference of 15 in. of water gage will suffice for an evaporation of 20 lb. of water from and at 212 deg. fahr. per sq. ft. of heating surface per hr. With an increase of the pressure difference, the evaporation likewise increases and it is found that the evaporation produced is proportional to the square root of the pressure difference which is applied. This pressure difference can be obtained in one of two ways, either by supplying the mixture to the boiler tubes under a positive pressure or by drawing away the products of combustion at the exit ends of the boiler tubes by means of a single fan.

As regards the process which takes place in a boiler tube of this type of boiler, it appears that the temperature in the granular packing at the entrance or firing end of the tube will approximate the calorific intensity of the gas employed. With coal-gas or coke-oven gas, the temperature at this point is in the neighborhood of 1800 deg. cent. (3272 deg. fahr.). This is the temperature in the center of the cross-section while the temperature of the granules in contact with the tube surface is very much lower so that the granular packing is red-hot or white-hot at the firing end, but its temperature decreases very rapidly along the tube. The functions of the granular packing are as follows: in the first place, the red-hot granules serve to insure absolute completion of combustion even in the absence of any air in excess of the theoretical requirements; in the second place, they radiate heat to the sides of the containing tube, thus largely accounting for the larger rate of heat transmission obtained, and in the third place, the granules even in that part of the tube where the temperature is so low as to prevent heat being communicated to any noticeable extent by radiation, serve to baffle the combustion products and hurl them rapidly and with violence against the tube walls, thus increasing the heat transmission through the fact of the hot gases impinging on the tube surface. For a given kind of packing in the tubes, there must be provided a definite ratio between the length and bore of the tubes in order to obtain sufficient cooling of the combustion gases. If it is desired to employ longer tubes of the same bore, this may be done without sacrificing considerations of economy by employing a packing material of a more open nature in the tubes. As regards heat losses in the boiler, several sources of these appearing in solid fuel boilers do not have to be considered in the surface combustion type, and in a Bonecourt type the combustion products leave the system at the temperature of about 110 deg. cent. (230 deg. fahr.), where a feed-water heater is employed so that the amount of heat carried away by the waste gases is very small, while owing to the compactness of the plant, the radiation loss is also small, amounting to about about two per cent. It appears therefore, that the heat utilized in steam generation varies from 94 to 95 per cent of the heat originally available in the gas burned.

The author describes in some detail the plan where this type of boiler is used as a link in the system of generating power from coal by means of ammonia recovery gas producers. In the described plant, conditions were established so that an expensive fuel such as the illuminating gas of London is advantageously employed for steam generation. The boiler is 8 ft. long and 3 ft. 6 in. in diameter and is provided with five tubes, each of 6 in. bore. It is capable of evaporating about 2000 lb. of water per hr., and is used for supplying steam to a steam hammer. The advantages of using this type are the readiness with which steam can be raised when wanted for the hammer and the immediate manner in which the making of steam responds to the turning on and off of the gas. A novel type of construction has been adopted for this boiler. The tubes instead of being of uniform bore throughout contract sharply at the entrance end, the first 6 in. of the tubes being only of such bore as is required for the supply of the gas mixture. This type of construction permits of dispensing with the use of the fire-clay plugs and the first part of the tube which conveys the gas to the fire-clay packing and is kept cool by the water in the boiler. The author states by the way that granular packing may be employed for the purpose of increasing heat transmission in so-called waste heat boilers where the heating medium consists of products of combustion from a furnace or gas engine. There is, of course, no surface combustion in the tubes of this kind of boiler as the granular packing serves merely to increase the heat transmission through the walls of the tube by radiating heat from the hot granules and also by causing the hot gases to impinge repeatedly on the tube walls. In addition to the gaseous fuel or hot waste gases, Bonecourt boilers can be fired also with liquid fuel. In this case practically the same processes occur, since the combustion of liquid fuel is only a special case of gaseous combustion: when liquid fuel burns, it is really the combustible vapors given off by it that are burned. But special methods for securing complete combustion of liquid fuel in contact with or in close proximity to water cooled surfaces have to be developed for this purpose. The boiler which is now used in the works of Bonecourt Surface Combustion, Ltd., in London is 5 ft. in diameter and 12 ft. long and is furnished with five boiler tubes, each 9 in. bore. The boiler tubes are packed with refractory material arranged on the staggered plan. The liquid fuel is supplied to the boiler tubes under the pressure due to a head of about 12 ft. The air required for the combustion is supplied from a fan at the pressure of from 5 to 30 in. water gage, the oil being spread by the air. There is at the entrance of each boiler tube, a gasification chamber for the spray of liquid fuel. The purpose of this chamber is to gasify or at least to partly gasify the liquid fuel. This gasification is brought about by the heat of the chamber and the partial combustion of the liquid fuel which later serves to maintain the chamber at the required temperature. The chamber is far too small to enable complete combustion of the fuel to take place. The following are the results of a test carried out on the oil-fired boiler referred to at the London Works of the Bonecourt Company:

Steam pressure, gage (per sq. in.)	110 lb.
Temperature of oil	80 deg. fahr. (27 deg. cent.)
Air pressure	37 in. of water
Pressure in smoke-box	3 in. of water
Temperature of combustion products leaving boiler tubes and entering feed-water heater	608 deg. fahr. (320 deg. cent.)

Temperature of combustion products leaving feed-water heater	275 deg. fahr. (135 deg. cent.)
Temperature of cold feed	43 deg. fahr. (6 deg. cent.)
Temperature of feed from feed-water heater to boiler	119 deg. fahr. (48 deg. cent.)
Duration of test	3 hr.
Total water evaporated	7,625 lb.
Water evaporated per hr.	2,542 lb.
Water evaporated per hr. from and at 212 deg. fahr.	3,085 lb.
Total tube surface (five tubes 9-in. bore 12 ft. long)	141 sq. ft.
Total heating surface of boiler	123.7 sq. ft.
Steam raised per sq. ft. of heating surface per hr. from and at 212 deg. fahr.	25 lb.
Total oil burned	545 lb
Oil burned per hr	181.7 lb.
Water evaporated from and at 212 deg. fahr. per lb. of oil	17.0 lb.
Net calorific value of oil (per lb.)	17,800 B.T.U.'s

$$\text{Efficiency} = \frac{7625 \times 1175.9 \times 100}{545 \times 17800} = 92.5 \text{ per cent}$$

A continuous sample of the combustion products was taken during the test, and was found to analyze:

	Per cent
Carbon-dioxide	12.8
Oxygen	3.4
Carbon-monoxide	0.0
Nitrogen	83.8
	100.0

The points which characterize this boiler may be enumerated as follows:

1. Complete combustion of the oil, no products of partial combustion being found in the flue gases.
2. The air required for complete combustion of the oil is only slightly in excess of the theoretical requirement.
3. Entire absence of smoke when once the boiler has been started up, and practically no smoke while starting.
4. The oil is supplied to the boiler cold and at a very low pressure, the air supplied for the combustion being sufficient to effect the necessary spraying of the oil.
5. The combustion products are cooled down to a point below which further cooling would scarcely be practicable or economical.
6. An evaporation of 25 lb. of water per sq. ft. of heating surface per hr.
7. The effective transmission to the water in the boiler of 92.5 per cent of the net heat available in the oil burned, even when evaporating at the above stated high rate.
8. Exact and immediate regulation of steam production.

RAILWAY CLUB OF PITTSBURGH

Vol. 13, no. 7, May 22, 1914, Pittsburgh, Pa.

Some Ill Effects of Boiler Feed Waters and Their Causes. W. A. Converse (40 pp., 30 fig. d). The article presents a very comprehensive discussion of ill effects of boiler feed waters and their causes covering both the theory of boiler scale formation and corrosion and some of the practice. The author gives also a number of analyses of boiler feed water and discusses the action of such waters in the light thrown on its composition by the analytical data. Thus, in one case he finds that water containing quite a large amount of carbonate of soda (22.789 grains per gal.) produced a deleterious effect on the condition of the gaskets. He explains that this was due to the fact that the gaskets upon the market to-day are largely made up either of asbestos or asbestos composition or of rubber or rubber composition, both of which are to a large extent soluble in strong alkaline solutions. Control experiments have been made and have shown that no such troubles are experienced where water is used containing practically the same amounts of the substances other than the soda salts. In another analysis, a large amount of sulphate of lime (41.989 grains per gal.) was found. The water gave rise to strong formation of scale and in addition produced serious corrosion underneath the scale. This is an interesting fact because it is not uncommon to find that an assumption is made to the effect that boiler scale protects the metal from corrosion. This may be true in most cases but in the present instance, it was found that under the layer of the scale, there was an action going on identically similar to that of sulphuric acid upon iron. The water itself, however, was not acid and contained no free sulphuric acid which consequently must have been a liberated product. It would appear from the investigation thus far carried on that the sulphate of lime which constituted the greater part of the scale decomposed at a temperature reached when the scale had become of sufficient thickness. Sulphur was liberated and attacked metallic iron. The sulphate of iron formed as the result of initial corrosion being a very unstable salt, broke down under the action of temperature and moisture, and again liberated sulphuric acid, leaving behind the iron in the form of iron oxide. A cyclic or continuous action took place therefore, and a comparatively small amount of sulphuric acid produced a very large amount of corrosion. The proof that the process occurred substantially as above described could be obtained by taking into consideration that sulphate of lime does not break up below a certain temperature. When accordingly, by means of mechanical devices, the scale formation in the boiler in which the experiment was carried on, was turbined down to half its original thickness and kept at it, it was found that no corrosion underneath the scale formation took place as the temperature at the point of contact was kept below the limit of liberation of sulphuric acid.

In the next analysis, a comparatively large amount of suspended matter was found with accompanying foaming when the water was used in the boiler. An experiment was carried on for the purpose of determining whether or not the foaming was due to the presence of precipitated carbonates. The feed water was treated in such a manner as to remove about one half of the carbonates of lime and magnesia, shown by analysis, and then pumped into the boiler; it was found that it was possible to operate the boiler over a period of 60 days with no trouble from foaming. Further experiments developed the fact that the same results could be obtained by changing the carbonates into other substances by chemical reaction at a much lower cost. The analysis in the same instance developed that the presence of black putty-like substance in the cylinders of the engine was due to the presence of carbonates of lime and magnesia in the water since this substance was nothing but a mixture of such carbonates with cylinder oil. Since oil itself carried none of them, the only way for them to reach the cylinders was by being carried over mechanically with the steam. This trouble

can also be overcome by changing the nature of the precipitated substances by chemical reaction.

The author presents further analyses which confirm the contention that ill effects of water are not exclusively attributable to the quantities of substances contained, but more particularly to their relative amounts. In two cases, water contained considerable amounts of chloride of magnesia. In one case, there was a serious corrosion above the water line, in another, there was none. The former was clearly due to the decomposition of the chloride of magnesia and formation of a very dilute solution of hydrochloric acid, while in the second case, corrosion did not occur because along with the chloride of magnesia there was a considerable amount of carbonate of lime present which combined with the hydrochloric acid liberated, and produced chloride of lime. In other words, there may be in the water substances neutralizing the injurious action of other substances present.

Further analysis establishes the interesting fact that water may contain very small amounts of total solid matter and still be entirely unfitted for the duties of boiler feed water. Water containing 1.8 grains per gal. of total solid matter, or apparently an ideal water for boiler purposes, was used in a stationary plant with the result that it was found necessary to replace the cold water portion once in every six or seven months while no corrosion took place in the boiler. An investigation was carried out by taking four samples of water from the original source of supply near the inlet to the pipe system, near the outlet of the system, and from the pet-cock at the bottom of the water column. The analysis showed that the quantity of iron contained in sample from near the inlet corresponded with that contained in the sample from original source but in the sample from near the outlet, two and a half times as much iron was found which showed conclusively that the water dissolved iron in passing through the pipe system. In the case of the sample from the boiler, there was found a large amount of iron held in suspension but the same amount in solution as was found in the sample taken from near the outlet of the cold water system which showed that in passing through the pipe in question, the water had taken up as much iron as it could hold in solution and did not exert a corrosive action on the boiler on account of it being already saturated. The author passes then to a discussion of the ionic theory of solutions and its bearing on corrosion in boilers.

In the discussion which followed, the question was brought up as to pitting of locomotive boilers which had been taken out of service, drained and set aside for a considerable time. Locomotives which had been set aside and filled with water remained in perfect condition at the end of the same period. The speaker explained that there was possibly greater action of free oxygen when the boiler was left open with air circulating through it. Another condition that might govern in this case is the permeation of the air in the empty boiler with sulphur gases always present in the atmosphere about shops where much coal is used as a fuel. It is, therefore, as a general rule, a much safer plan to keep boilers filled with water rather than leave them empty.

ROYAL SOCIETY

Proceedings, Series A, vol. 90, no. A 619, July 1, 1914, London

ON THE FLOW OF METALS UNDER LARGE CONSTANT STRESSES, E. N. da C. Andrade (15 pp., 5 figs. *e*). The article presents the data of a research having for its object the examination of the general laws of flow in metallic wires when extended so as to cover the region of large permanent set by stresses kept constant throughout the flow. One of the purposes of the investigation was to see if very pure metals behaved in the same way as commercial metals, and whether it was true that the non-viscous character of the initial part of the extension time curve was due to impurities. In the course of the research a type of flow not hereto observed was found. To test the flow under constant stress, the device of the hyperbolic weight was employed; by the use of such a weight sinking as the wire stretched into a liquid of suitable density, the effective load was diminished in such a way that the stress over the cross section remained constant as the wire thinned. All the metals investigated except mercury were used in the form of wire while for mercury a special method was resorted to. The iron and copper wires were carefully annealed, and after this treatment gave consistent results. It was found that without exception all the single metals (not alloys) gave at the various temperatures investigated, curves of extension against time which could be closely represented by the formulæ:

$$l = l_0 \, (1 + \beta \, t^{\frac{1}{3}}) \, e^{kt}$$

by assigning suitable values to the constants. The constants l_0, β, and k are not purely artificial but have a physical processes corresponding to each one of them: that is l_0 represents the immediate length of loading, β is the coefficient which gives a measure of that part of flow whose rate decreases as the time increases, and k measures the final flow which proceeds viscously.

The curves for iron at 444 deg. cent. resembled those for lead at 16 deg. cent. and there was no difference of type. The main result of this part of the work was to show that typical metals of widely different nature obeyed the same general laws of flow and that the apparent difference of type disappeared when a wide range of temperature was considered. The higher the temperature for a given metal, the more the viscous type of flow predominated. Small impurities did not affect the general type of extension curves and pure mercury at — 78 deg. cent. had much the same curves as soft commercial iron at 444 deg. cent. It has been further shown that for metals the flow tended to become in every case finally viscous and an investigation was made to discover if possible what change was produced in the metal which sets it in a condition to flow viscously and how the change could be effected. It was found that by extending the wire rapidly under a large stress for a short time it could be put in a condition to flow viscously from the start when subject to a smaller stress. The more rapid the preliminary extension, the smaller the rate of the viscous flow under the subsequent smaller stress. It has also been found that severe preliminary twisting would put the wire in a state to give the viscous flow almost from the start. With increasing amount of preliminary twist, the rate of flow first of all decreased, but reached a minimum, and then increased slowly, probably owing to tears in the metal. A twist of a given number of turns was more effective in hardening the metal if it was applied half in the one direction and then half in the other than if it were applied all in one direction.

PERSONAL NOTES

John W. Nickerson has accepted a position with the Cheney Brothers Silk Mills, in South Manchester, Conn., as industrial engineer, having recently resigned from a similar position with the Sayles Bleacheries, Saylesville, R. I.

S. Warren Potts has resigned as mechanical engineer of the E. W. Bliss Company, Brooklyn, to accept a similar position with R. Hoe & Company, New York.

Lucius L. Moses has opened an office as consulting engineer in Seattle, Wash.

Frederick L. Farrell has resigned from the B. F. Sturtevant Company, New York, to enter the employ of the Green Fuel Economizer Company, also of New York.

Victor E. Schniedeknecht, designer for the Aurora Automatic Machinery Company of Chicago, has accepted a similar position with the Pneumatic Jack Company, Louisville, Ky.

Henry Martin Leland has become president and advisory manager of the Cadillac Motor Car Company, Detroit, Mich.

Forrest E. Cardullo, professor of mechanical engineering at New Hampshire College, Durham, N. H., has resigned to take a position in the University of Texas, Austin, Tex.

Henry E. Longwell, formerly consulting engineer for the Westinghouse Machine Company, is now general manager of the Westinghouse Air Spring Company, New Haven, Conn.

Ferdinand Jehle, formerly associated with the Commercial Engineering Laboratories, Detroit, Mich., has been appointed laboratory engineer for the Automobile Club of America, New York City.

Samuel S. Webber, recently resigned as chief engineer of the Trenton Works of the American Steel & Wire Company, Trenton, N. J., after 25 years of service.

R. E. Chandler, dean of engineering of the Oklahoma Agricultural and Mechanical College, has resigned to become head of the mechanical engineering department of the New Hampshire College, Durham, N. H.

R. H. Danforth, for the past six years with the United States Naval Experiment Station and the post graduate department of engineering of the United States Naval Academy, Annapolis, has been appointed professor of hydraulics and mechanics at the Case School of Applied Science, Cleveland, Ohio.

W. C. Rowse, who has been experimental engineer with the Cutler-Hammer Manufacturing Co., New York, since April 1913, has been appointed professor of mechanical engineering at the University of Manitoba, Winnipeg, Manitoba, Canada, and will take up his new duties September 1.

Frederick B. Garrahan has severed his connections with the International Nickel Co., Bayonne, N. J., to accept the position of superintendent in charge of steam shovel work of J. N. Bastress & Co., Fern Glen, Pa.

EMPLOYMENT BULLETIN

Note: In sending applications stamps should be enclosed for forwarding.

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

POSITIONS AVAILABLE

715 Small factory in Massachusetts building box machinery and saw mills, desires superintendent. Man familiar with modern machine shop and foundry practice; 32 men employed.

721 Technical graduate, with some experience as machinist and in erecting and installing machinery; headquarters Chicago. Salary about $100 per month.

801 Lecturers in general mechanical engineering subjects for the coming season; Canadian University; approximate salaries $1250 to $1500.

802 Assistant engineer for small concern in Eastern Pennsylvania, to have charge of handling of orders, estimating, assist chief draftsman in interpreting orders and correspondence, handling of all correspondence in connection with orders, sales records, and possibly occasional selling. Apply by letter.

804 Young engineer with several years experience, wanted for condenser department of Philadelphia concern, to lay out condenser plants and make necessary estimates and calculations. Graduate of the mechanical engineering department of the University of Pennsylvania preferred. Apply by letter.

805 Young engineer, recent graduate or with possibly a year's experience; work will consist of boiler tests, gas analyses, sampling of coal and ash, and possibly some steam engine indicator work and miscellaneous testing. Salary sixty dollars a month.

MEN AVAILABLE

I-900 Student member, eight years experience mechanical drafting room, one year civil engineering, steel works, and two and one-half years superintendent in small shops, desires position as assistant superintendent in large shop or superintendent in small shop.

I-901 Graduate mechanical engineer, age 30, married, at present holding responsible executive position, plant manager, with small manufacturing concern, desires a similar position or one as assistant to superintendent or manager with company with good chance for advancement. Six and one-half years varied engineering experience. Specialty, pressed steel both light and heavy.

I-902 Associate-Member, age 29, experience in design and development of marine motors and gas tractors, boat building, reconstruction of automobiles and trucks; technical correspondent and systematizer; experimenting and investigating work. Inventive ability along practical lines. Position desired as designing or experimenting engineer or executive. Can make a good proposition to capitalist to develop marine oil engine for specialized field.

I-903 Member, technical graduate, experienced in executive work of large corporations, also wide training in the requirements of a corporation or consulting engineer for work such as design of power plants and machinery, their construction, maintenance and operation, purchasing and executive charge of engineering work. Desires a position as works manager or superintendent.

I-904 Graduate mechanical engineer, age 28, married, seven years experience as machinist, toolmaker and master mechanic. Desires position in testing work, design or teaching.

I-905 Member, age 30, mechanical engineer, 14 years experience as draftsman, checker, designer and manager, last employed as American representative for large English engineering firm taking entire charge of sales, advertising, developing new ideas, and general office work. Has traveled all over United States. Desires similar position. Can furnish best references. Location New York.

I-906 Member with education and experience as marine engineer desires to communicate with any persons intending to fit out sea-going ships under the American flag in the present European crisis. Is profitably employed and is willing to consider only a more profitable connection.

I-907 Junior, graduate mechanical engineer, two years experience in power plant engineering and two years indus-

trial engineering, systematizing and managing large plant, desires position with engineering firm or in industrial plant.

I-908 Junior member, M. E. Purdue University, age 26, careful, painstaking, progressive, executive ability, three years experience in machine and power plant design, at present and for past year in charge of erection and equipment of factory buildings. Desires to locate permanently with reliable concern as assistant to mechanical engineer or works manager. Best references.

I-909 Junior member, graduate mechanical engineer, age 27, three years drafting and general engineering experience, desires position with engineering or construction company. Salary $100 per month. Location immaterial.

I-910 Member, mechanic, designer, organizer and executive, good ability, practical experience, interested in devising methods for reduction of manufacturing costs, desires position along these lines with progressive company, or would join smaller company in position requiring all-round experience.

I-911 Member, mechanical engineer, twenty years experience in power plants, heating, ventilating, plumbing, machine tools, refrigerating machines, gas and oil engines and general engineering work, inventive and executive ability, English, French and German correspondent, desires position with consulting engineers. Salary $3000. Location New York or vicinity.

I-912 Junior, M. E., age 24, experienced in design high grade stationary machinery, engines, hoists, compressors, blowers, pumps and condensers, desires position where this experience will be of value. At present employed but desires to locate in New York or vicinity.

I-913 Member, age 32, 12 years experience, desires position as executive or mechanical engineer. Can take full charge of engineering department with concern that wants results and where there is opportunity to advance. Salary $2700-3600. At present employed.

I-914 Student member, age 25, experience in gas engine work as tester, experimental, and assistant engineer with one of the oldest and largest concerns in the country, desires position with gas engine manufacturing company, preferably small, along these lines.

I-915 Sales engineer, technical graduate, ten years experience in successful plant operation and management, desires position in steam, hydraulic and mill equipment. Salary and commission. At present employed.

I-916 Junior, technical graduate, age 25, married, five years experience in shop and office on light machinery and electrical specialties, desires executive position. Salary secondary consideration if opportunity for advancement is good.

I-917 Member, mechanical engineer, graduate of leading technical school, five years' experience in machine shop as machine designer; twelve years experience as patent attorney, has been admitted to Bar. Desires position of responsibility in patent law department of manufacturing company. Some inventive ability.

I-918 Junior, age 38, broad experience in handling high grade mechanical specialties and acquaintance in manufacturing and engineering fields, desires to represent manufacturer in East or Middle West.

I-919 Junior, age 27, graduate mechanical engineer, four years experience in general plant work, including drafting room and shop, desires position with chance for advancement. At present employed.

I-920 Mechanical engineer, ten years experience drafting and machine design, last four years experimental work, desires position along these lines, or as chief engineer, assistant to superintendent or outside man.

I-921 Mechanical engineer, age 30, experienced in pumps and pumping machinery, gasolene, oil and steam engines, sugar house machinery, drawing and erection room, also sales experience, desires responsible position.

I-922 Member with exceptional mechanical and electrical technical training, five years experience in research work on steam turbines and centrifugal air compressors, five years chief engineer complete charge of designing, manufacturing, testing and installing vacuum cleaner systems, including development of portable and stationary vacuum cleaning machines, desires position where his experience and training can be applied. Development engineering preferred.

I-923 Junior, age 27, technical graduate, nine years experience in drafting and design of steam power and industrial plants, heating and ventilating systems, also testing, desires position with broader outlook as mechanical engineer or assistant to superintendent of industrial firm. At present employed. East or Middle West preferred.

I-924 Stevens graduate, age 23, past thirteen months with large steel company, desires position with industrial engineers or as assistant to manager of an industrial concern.

I-925 Member, Cornell graduate, two years post graduate study in Germany, age 39, four years experience as instructor and ten years as designer of steam engines and steam turbines, desires position as assistant professor of mechanical engineering.

I-926 Member, technical graduate, age 35, with shop, design, sales and management experience, wide acquaintance with manufacturers in New England and having an established office in one of the leading manufacturing cities in Connecticut, desires to act as manufacturers' agent for responsible companies.

I-927 Graduate University of Cincinnati, age 24, four years experience as machinist, foundry experience, and one year's experience in power plan construction and design, would consider position with good chance for advancement, or as instructor in engineering or technical school.

I-928 Junior, age 32, technical graduate, post graduate course with large electric works, twelve years experience in design, construction and operation of power houses and substations, experienced in high voltage design and construction. Best references as to character and ability. Salary $200. Location New York.

I-929 Technical graduate, age 33, ten years experience in light metal manufacturing and foundry work; thoroughly familiar with modern and economic methods of shop management, seeks position as superintendent, preferably with large company. At present employed.

I-930 Mechanical engineer, ten years wide and varied experience in the lines of heavy and special machinery, also general manufacturing and maintenance work. Designing, testing and demonstration experience.

I-931 M. I. T. graduate in mechanical engineering, post graduate course in electrical engineering, twenty years experience in design and construction of machinery and buildings, manufacturing, systematizing and accounting, desires permanent position.

I-932 Mechanical engineer, fifteen years experience shop work, road work, power plant operation, design and testing, special, and automatic machinery, also heating, desires position in the East.

I-933 Factory superintendent or foreman, conversant with modern shop practice, executive and mechanical ability; twelve years practical experience production efficiency, maintenance and operation of industrial plants and equipment and systematizing of shops. Location immaterial.

I-934 Student member, M. E. 1911, desires position in shop of manufacturing concern with view to entering sales department.

I-935 Associate-Member thoroughly familiar with large compound condensing and non-condensing Corliss engines, also steam engine indicator practice, desires position as construction or operating engineer.

I-936 Electrical and mechanical engineer, 38, first-class executive, who has headed large organizations, both in constructional and manufacturing work, charge of important government work. Experienced in sales organization, aggressive and a good developer. Desires position with manufacturing or construction company. Apply through the Society.

I-937 Cornell graduate, mechanical and electrical engineer with fourteen years broad experience in the design, erection, operation and appraisal of public service and industrial properties, factory operation and maintenance; and sales engineering. Desires a permanent position with consulting engineers or manufacturing company in or near New York City. Appraisal engineering preferred.

I-938 Student Member, age 23, graduate of Middle West University, 1914 M. E., experience as machinist, mechanical draftsman and rate setter, desires position as assistant to superintendent or to manager of some industrial concern. Location immaterial.

I-939 Member, for the past 13 years connected in various capacities with the operation, extension and improvement of steam power plant systems and with successful record, desires to connect, preferably with an industrial concern wishing to employ a high grade engineer capable of operating a similar plant or chain of plants to best advantage and analytically treating economical development. Age 35. Married. At present employed.

I-940 Managing sales engineer, open for contract to build up business with New York as headquarters. Has specialized in power plant equipment, contractors and conveying machinery. Practical shop and field experience; diplomatic and progressive.

I-941 Member, technical graduate, several years experience designing, testing and erecting, desires position as chief draftsman, mechanical engineer or designer of steam pumps, simplex or duplex. At present employed.

I-942 Member, age 43, married. Three years at Mass. Inst. Tech., thoroughly experienced in railway car designing and building. All positions from draftsman to proprietor. Thorough knowledge of export business. 3 years in South America as salesman. Best references.

I-943 Member, technical graduate; 37 years of age; 15 years experience in teaching Manual Arts subjects, drawing and machine design, kinematics of machinery, building construction, steel and concrete construction, steam and other engineering subjects, desires to correspond with progressive concerns contemplating the engagement of a sales engineer. Exceptionally well-fitted both in training and personality for such a position. Location, preferably Eastern States.

I-944 Member, technical graduate, twelve years experience design and installation of power plants, heating and ventilating systems and shop equipments.

I-945 Junior, technical graduate with experience in shops, drafting room, test plant, engineering and erection departments of large manufacturing concern, desires position with engineering or manufacturing concern.

I-946 South American Markets. Mechanical and electrical engineer, nine years with large corporation, broad engineering and responsible executive experience, can arrange to go to South America with South American gentleman speaking Spanish fluently and familiar with business and social customs of those countries, for the purpose of investigating South American markets. Exceptional opportunity for American manufacturers.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

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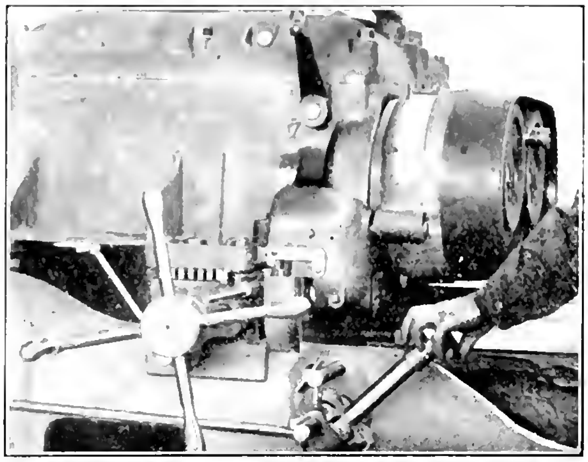
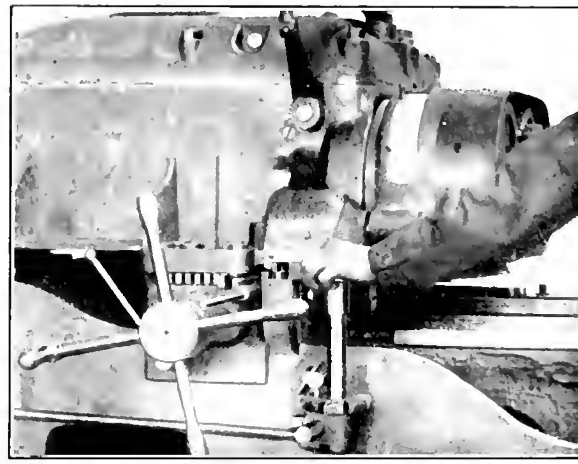
[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1914, and in the January and July 1914 issues of The Journal





Are You Responsible?

IS your O. K. desired when a new turret lathe is under consideration? If so, this information will be of interest to you.

The present day requirements demand something more than a lathe fitted up with a turret.

There are several makes of turret lathes on the market, and they differ as widely as high speed cutting steels; therefore, it is but justice to yourself to carefully note this information, and refer to it before putting your O. K. on the order.

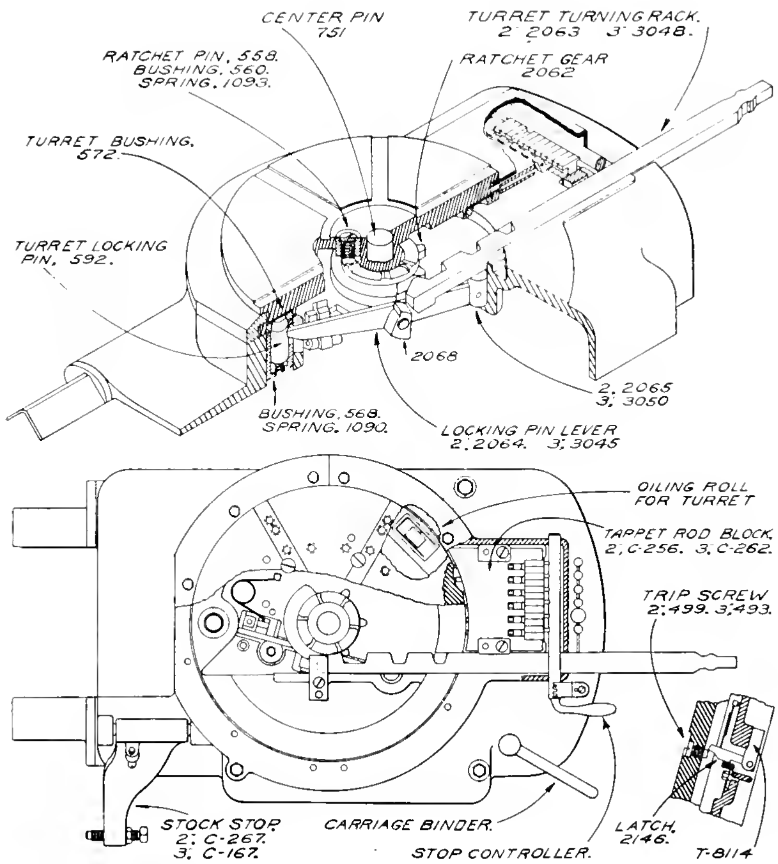
The object of a turret lathe is to reduce the time and cost per unit by reducing the number of operations, eliminating waste motion, superfluous operating parts and reduce the operator's movements to a minimum by having all operating parts in the most accessible place. Simplicity of construction offsets the heavy repair bills and idle machinery.

Every feature that tends to reduce the cost per unit and cost of upkeep, and improve the quality of workmanship adds a point to the usefulness of the machine and, what is very important to you—these points figure strongly in your estimates.

These are the points which govern the decision of the experienced buyer or mechanic—they are the points on which the known reputation of the Jones & Lamson Co. was built.

On pages 2 and 3 of the August issue of the Journal of the American Society of Mechanical Engineers, features of the Cross Sliding Head were described.

Some important features of Turret construction are given on the next page.


CENTER PIN
751
TURRET TURNING RACK.
2' 2063 3' 3048.
RATCHET PIN. 558.
BUSHING. 560.
SPRING. 1093.
RATCHET GEAR
2062
TURRET BUSHING.
572.
TURRET LOCKING
PIN. 592.
2068
2. 2065
3. 3050
BUSHING. 568.
SPRING. 1090.
LOCKING PIN LEVER
2. 2064. 3. 3045
OILING ROLL
FOR TURRET
TAPPET ROD BLOCK.
2. C-256. 3. C-262.
TRIP SCREW
2. 499. 3. 493.
STOCK STOP
2. C-267.
3. C-167.
CARRIAGE BINDER.
STOP CONTROLLER.
LATCH.
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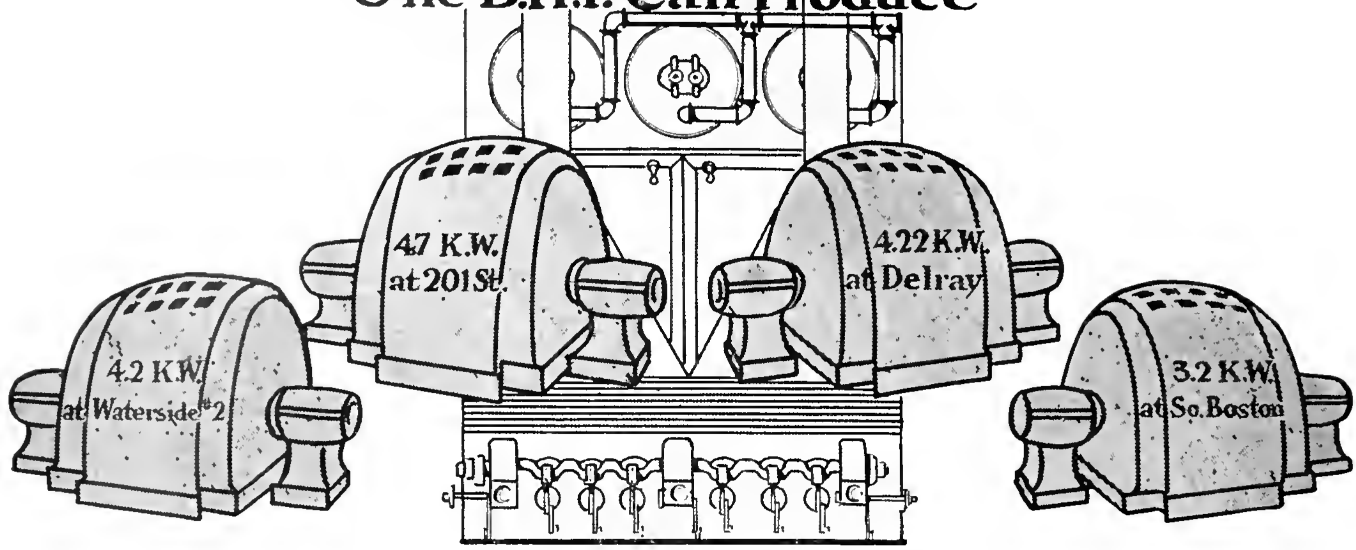
T-8114

One B.H.P. Can Produce



Boiler Horse Power and Output Capacity No Longer Bear A Fixed Relation—

Formerly a more or less definite equation of 1 b.h.p. = 1.25 kw. or 1 b.h.p. = 1.5 kw. was assumed in planning a power station.
But look over the central stations today. The turbine and improved systems of combustion have broken down that fixed relation—ratios of b.h.p. to kilowatts are being secured that would have dumbfounded the mechanical world a few years gone.

And it is significant that most of the remarkable cases of wide discrepancy between installed boiler horse power and kilowatt output (obtained or planned) are in plants fired by

The Taylor Stoker

For instance, the original ratio at New York Edison Waterside No. 2, of 1.5 kw. per boiler horse power, has been increased by TAYLOR STOKERS to 4.2. At the new South Boston Station of the Boston Elevated TAYLOR STOKERS have established a ratio of 3.2. The planned ratio at the new TAYLOR STOKERED 201st Street Station of the United Electric Light and Power Company is 4.7, while the 12-2365 h.p. boilers at the Delray Station of the Detroit Edison will be fired by TAYLOR STOKERS to produce a ratio of 4.22—*in emergencies* 5.65.

Please note also that there is another point clinching the argument in favor of TAYLOR STOKERS for these central stations—namely, their ability to build up such ratios *whenever* and *as rapidly as* the extra current is required.

Write our Stoker Department for a list of prominent industrial plants and generating stations equipped with TAYLOR STOKERS.

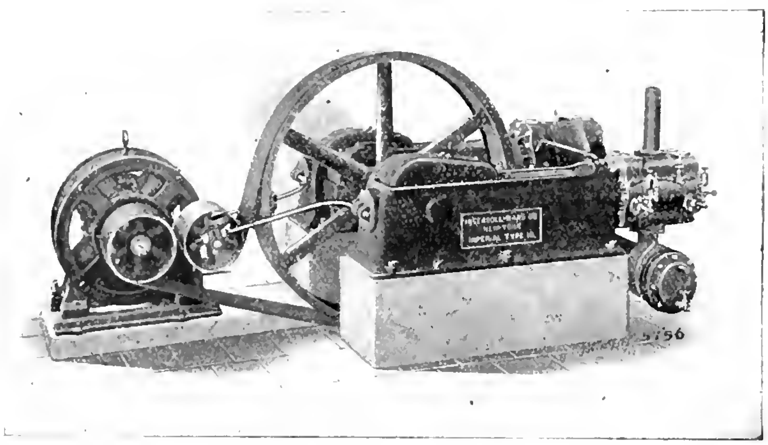
American Engineering Co.

Philadelphia

"IMPERIAL"

SHORT BELT DRIVE AIR COMPRESSORS

You will save expense and avoid belt troubles, economize on floor space, and secure a smoother running air compressor and one of great overall efficiency.



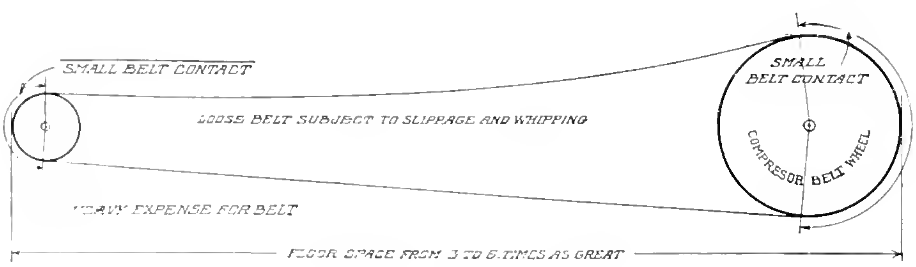
"Imperial" Short Belt Electric Air Compressors are furnished from stock, complete with motor, slide rails, starter, endless belt and Short Belt attachment, "Imperial" Combination Regulator, foundation bolts, washers, etc., all ready to connect to station wiring and receiver piping.

Here is What One User Says:

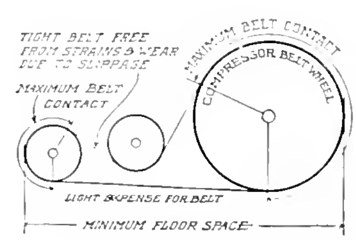
"We find the short belt drive on our XB-2 compressor entirely satisfactory and would recommend it for installation similar to ours.

There is no evidence of back lash on the belt. We have had this equipment in use one year and would much prefer the short belt drive to a gear driven compressor; my theory being that the flexible belt does not jar and rack the working parts of either compressor or motor as gear would.

There has not been one minute's trouble or delay with this compressor since it was started a year ago, and I feel that I cannot speak too highly of it."



Ordinary Long Belt Drive



"Imperial" Short Belt Drive

The above diagrams illustrate the difference in the two methods of drive.

Built in capacities up to 1500 cubic feet and pressures from 15 to 110 pounds—direct or alternating current.

Bulletin 3312

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44-C

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Globe Angle Check Gate

Jenkins Bros. Cast Steel Valves are specially built for superheated steam. They withstand the extremely high temperatures, the tremendous shifting pressures, and the violent changes in expansion and contraction incident to this kind of service.

The steel used is made from selected irons, and for strength, ductility and soundness the castings are fully equal to those produced commercially by any known process. The seat rings, discs, bushings and spindles are made of Monel Metal, a natural alloy, containing about 70% nickel, of great tensile strength. The valves will safely carry a working steam pressure up to 350 pounds, and total temperature of 800 degrees F. No Engineer can afford to take chances with superheated steam. With Jenkins Bros. Extra Heavy Cast Steel Valves you may be sure of a maximum safety and economy with a minimum of danger and trouble.

We invite your inquiries, and shall be glad to furnish estimates

All Genuine Jenkins Bros. Valves Have the Diamond Trade Mark— Your Protection

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DE LAVAL
Centrifugal Pump
will supply more water at less cost

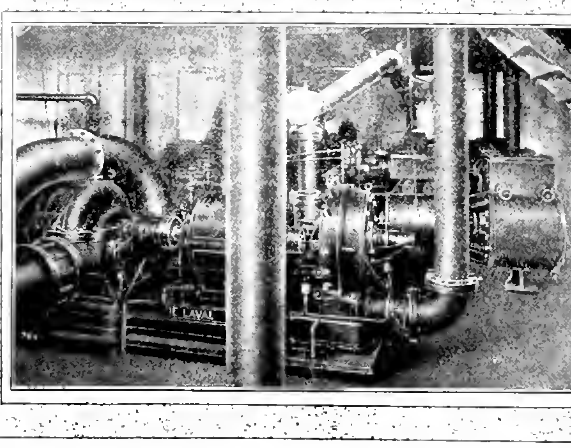
THE cost of pumping with a De Laval Steam-turbine-driven pump is less than with a reciprocating pump. The overhead charges are greatly reduced as compared with triple-expansion, crank-and-fly-wheel engines, while the steam economy is better than that of compound engines or of direct-acting reciprocating pumps.

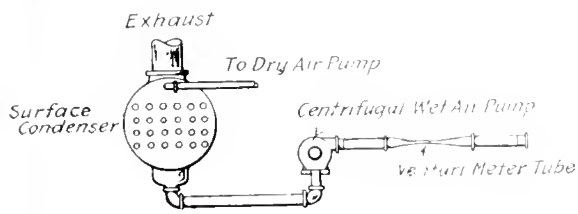
If you have reciprocating pumps of low or moderate efficiency already installed, it will pay to put in a De Laval Centrifugal Pump driven by a De Laval Low-pressure or Mixed-flow Turbine to run on the exhaust of the reciprocating pump. In this way, the capacity and economy of the plant may be increased 50 to 75%, without installing more boilers or burning more coal.

If you are interested in pumping problems, send for our new 300-page book, B. 58.

DE LAVAL
Steam Turbine Co.

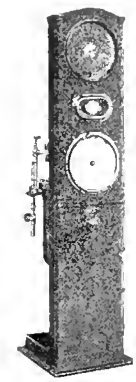
Trenton 138 **New Jersey**





Unique Use of a Venturi Hot Water Meter

Venturi Meter Reveals Cause of Condenser Troubles


Type M Register-Indicator-Recorder

The surface condenser of a certain 8,000 K.W. steam turbine generator unit was giving trouble and at times of lightest load the vacuum was poorest. The centrifugal wet air pump ran at a constant speed and to all appearances it was working satisfactorily.

In order to determine the nature of the trouble a 4 inch Venturi Meter was set in the discharge pipe from this pump and it showed that the rate of pumping fluctuated through wide limits. Upon careful examination it was found that the water was pumped from the condenser much faster than the steam was condensed. Each time the condenser was pumped entirely dry the suction of the pump was lost and it was not regained again until the water level rose to the level of the center of the pump.

A change was therefore made in the method of driving pump so that its speed could be reduced during the hours of light load and this overcame all of the trouble experienced.

The nature of the trouble as found was different from what had been expected and had it not been for the meter a prolonged and possibly costly examination would have been made in other directions. Venturi Meters can introduce savings in your plant.

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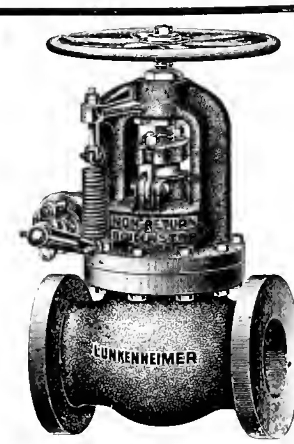


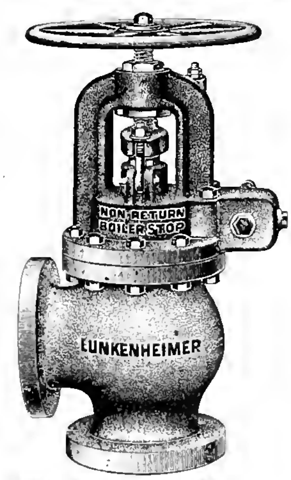
NON-RETURN SAFETY BOILER STOP VALVES

Prevent steam from other boilers of a battery discharging into one that is disabled. A sudden decrease in pressure in any boiler will cause a Lunkenheimer Non-return Safety Boiler Stop Valve attached to that boiler to immediately close, and will not open until the pressure equalizes that of the other boilers in the battery.

Among other products manufactured by The Lunkenheimer Company may be mentioned Globe, Angle, Cross, Check, Lever, Gate, Pop Safety, Relief, Throttle, Blow-off, Screw Down Check Valves, etc.; "Puddled" Semi-steel and Cast Steel Valves of all types; Water Columns, Gauges and other Boiler Mountings; Whistles and Ground Key Work of all descriptions; Injectors and Ejectors; Lubricators and Lubricating Devices; Oil Pumps, Oil and Grease Cups, Gasoline Engine Appliances, etc.

Your local dealer can furnish them; if not, write us.

A complete description, with illustrations of the entire line, can be had by referring to Lunkenheimer Catalogue No. 50. Write for a copy.



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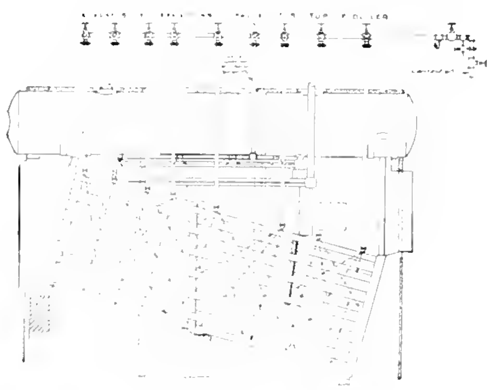

VULCAN SOOT CLEANER
Top Installation

because the VULCAN SYSTEM proved to be the easiest and quickest way of getting rid of soot. SIDE BLOW DOORS WERE OMITTED to prevent air leakage. The VULCAN, by being installed thru the top of the boiler, permitted the boilers to be set closer together, thereby **saving valuable floor space.**

Send for our book "Economical Steam Production" on the subject of "Soot in Relation to Boiler Efficiency." It is of much interest to Mechanical and operating engineers. A complimentary copy will be mailed promptly upon request.

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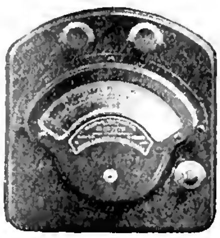
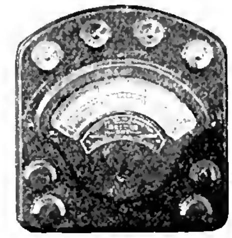
Miniature Precision Instruments for Direct Current

A new group of very small Indicating Instruments

COMPACT — ACCURATE — DURABLE — BEAUTIFUL



MODEL 280, Single Range Portable Voltmeter. (One-quarter Size.)



MODEL 280, Triple Range Portable Volt-Ammeter (One-quarter Size.)

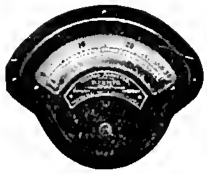
PORTABLE

Voltmeters, Millivoltmeters, Volt-Ammeters, Ammeters, Mil-Ammeters, are supplied in single, double and triple ranges.

The triple range volt-ammeter comprising six instruments in one. This group also includes BATTERY TESTERS.

SWITCHBOARD

Voltmeters Volt-Ammeters Ammeters Mil-Ammeters



MODEL 267, Switchboard Ammeter. (One-quarter Size)

MODEL 268, Switchboard Volt-Ammeter. Reads Amperes. Press Button for Volts. (One-quarter Size.)

This new line of instruments represents the latest development of the pivoted moving coil, permanent magnet type for low ranges.

The refinement of design and mechanical work in them has been carried to a degree which would appear to be almost impossible of accomplishment, if the results were not evident in the instruments themselves.

They embody characteristics which have made the well known Weston Standards famous throughout the world.

They are accurate, dead beat and extremely sensitive.

They may be left continuously in circuit at full load without injury and are shielded against the external electrical and magnetic influences of other apparatus in their vicinity.

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They have the longest scale ever provided in instruments with equal length of pointer.

Each model has been thoroughly tested under the most severe conditions of service and in experiments extending over more than one year.

The portable instruments may be conveniently carried in the coat pocket.

The prices have been established upon so low a scale that any one may possess one or more of these remarkable instruments at moderate cost.

If you cannot obtain the instruments desired from your dealer, write us.

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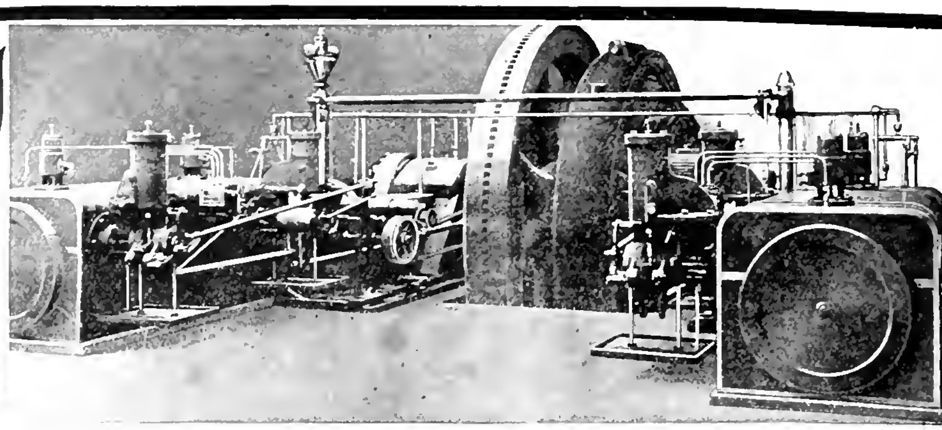

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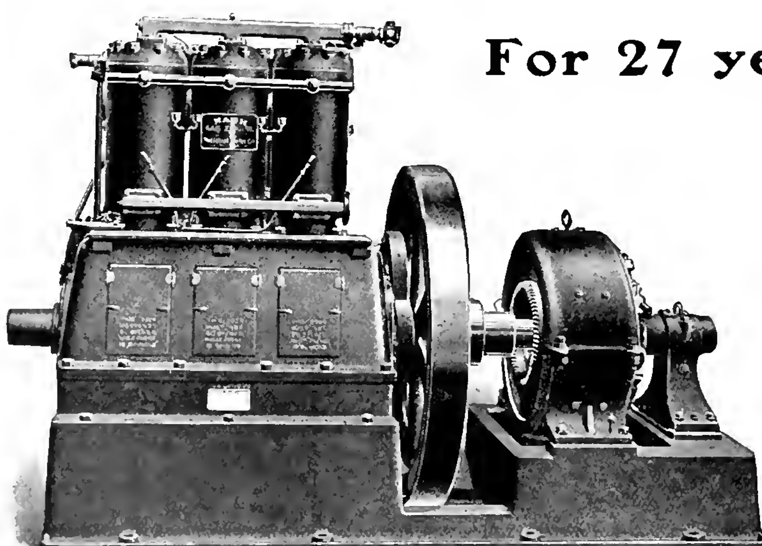

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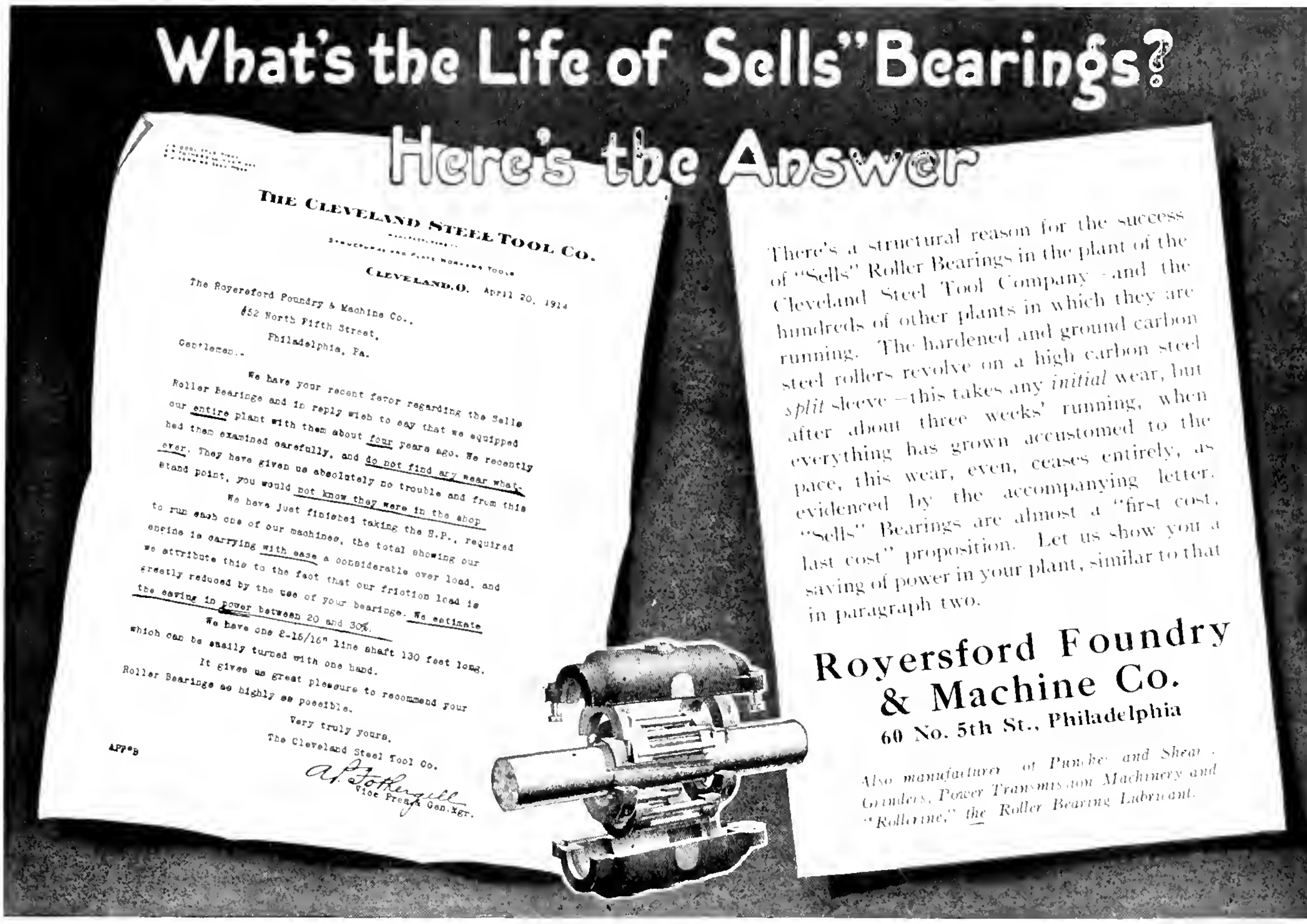

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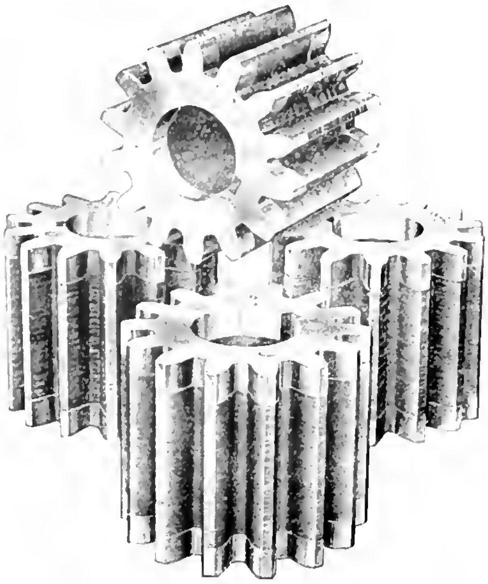

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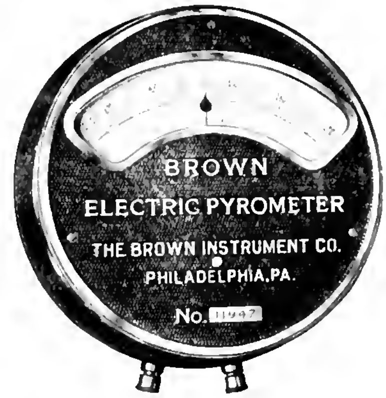

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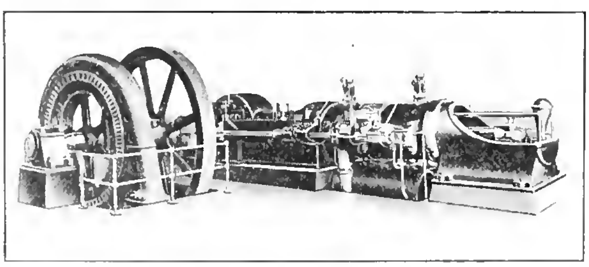

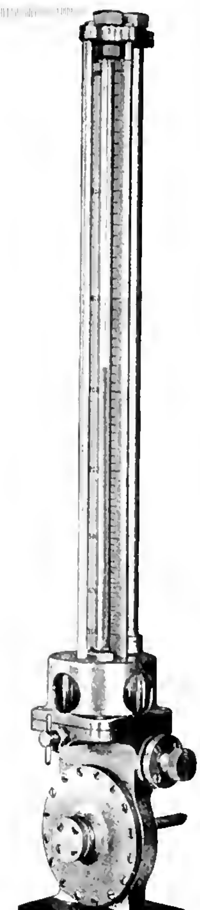

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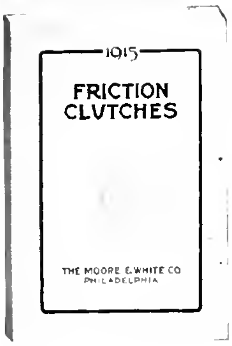

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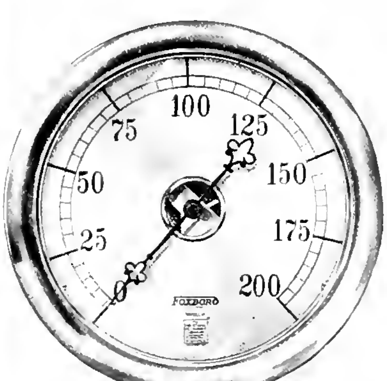

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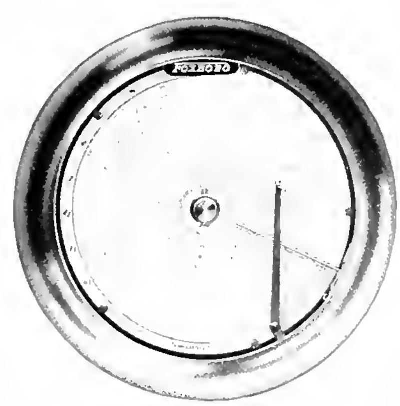

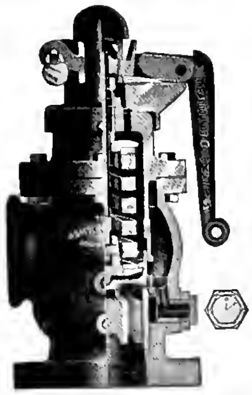

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Manufacturers of a complete line of Power Transmission Machinery for belt, rope or gear driving, including the well known Hill Friction Clutches and Hill Collar Oiling Bearings.

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Papers on Air Compressors and Pneumatic Tools

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Gas Holders
Pumping Machinery
Hydraulic Machinery
Gas Producers

PAPERS PUBLISHED BY A. S. M. E.

No. 381. Standard Method of Conducting Duty Trials of Pumping Engines: Committee Report, price $0.30; No. 1144. Balancing of Pumping Engines: A. S. Nagle, price $0.10; No. 1110. Development of Water-wheel Governor: M. A. Replogle, price $0.20; No. 1113. Turbine Design as Modified for Close Regulation: G. A. Bovinger, price $0.10.

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THE JOURNAL
OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

29 West 39th Street, New York

The Journal of The American Society of Mechanical Engineers

Including the Transactions of the Society

October · 1914

THE ENGINEER'S PART IN PROMOTING PROSPERITY

AT the present time, as never before, America must place dependence upon its own resources and its own industries. Almost every one of these industries is dependent upon the work of the engineer. Now as never before he must show his ability to direct "the great sources of power in nature for the use and convenience of man." It is a time for coöperation and mutual assistance which can come only from association with those from the various fields of engineering activity.

The American Society of Mechanical Engineers endeavors to provide opportunities for such coöperation through its meetings. Beginning in October, there will be regular meetings in fifteen of the largest industrial centers of the country. Each member is earnestly requested to invite his friends and associates to these meetings, so that they may participate in the work and help solve the many problems confronting the profession.

The address of any one you would like to have invited to the meetings, sent to the Secretary, will secure a cordial invitation from the Society entitling your friend to the privileges of a meeting.

Total Membership of the Society, September 28, 1914........................ 5995
New Members since January 1, 1914.. 709

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

Volume 36 OCTOBER 1914 Number 10

CONTENTS

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The American Society of Mechanical Engineers

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COMING MEETINGS OF THE SOCIETY

October, Boston, Mass. Subject: Flow Meters. The date of the meeting can be secured from the Secretary of the Boston Committee on Meetings.

October 8, Philadelphia, Pa. Joint meeting with the Franklin Institute. Paper: Recent Development in Cast Iron Manufacture, by J. E. Johnson, Jr.

October 15, Cincinnati, Ohio. Joint meeting with Engineers Club of Cincinnati. Address: The Testing of the Motor Vehicle Engine, by Frederick R. Hutton.

October 22, Buffalo, N. Y. Address: Engineers and Public Service, by Charles Whiting Baker.

October 22, St. Paul, Minn. Subject: Power Developments on the Mississippi River between St. Paul and Minneapolis, Adolph F. Meyer.

November 10, San Francisco, Cal. Subject to be announced.

November 18, New Haven, Conn. Fall meeting with afternoon and evening sessions, Mason Laboratory of Mechanical Engineering, Sheffield Scientific School, Yale University. Subject: The Generation and Application of Electricity in Manufacturing.

Annual Meeting, December 1–4, New York City. There will be a session on Engineering Metals, particularly Steels of Construction and for Tools; Cast Irons; and Alloys of Copper, Tin and Aluminum, etc.; and the entire day on Thursday, December 3, will be devoted to the general subject of Engineering in connection with the Administration of a City, the meeting to be opened by the Mayor of the City of New York. The sub-committees on Railroads and Machine Shop Practice are arranging for sessions, and there will be one session at which several important miscellaneous papers will be read.

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

Volume 36 October 1914 Number 10

THE ANNUAL MEETING

DECEMBER 1-4, 1914

It is expected that there will be two features of the Annual Meeting which alone will make the meeting distinctive and of wide-spread interest. The first of these is the important all-day session on Thursday, December 3, on the Engineer in Public Service, when papers upon municipal engineering and related topics will be presented. Contributions have been arranged for upon a wide variety of subjects such as is indicated in the following tentative list: The collection and disposal of refuse from an engineering standpoint and the utilization of municipal wastes; the handling of sewage sludge; the training of municipal employees; the cleaning of public buildings; the future of the police arm presented from the engineering side; the problem of organization as related to the highway department; controlling factors in municipal engineering; cleaning filter sands; the design and operation of a municipal electric light plant; and municipal colleges in Germany. The session will be opened by John Purroy Mitchel, Mayor of the City of New York. Arrangements for the session are being completed by the Committee on Public Relations, and it promises to be one of the most attractive and largely attended meetings which the Society has held.

The other feature referred to is that of the reports which are expected for the Wednesday morning session. As is known to the membership, two of the most important reports ever undertaken by the Society are nearing completion, and it is hoped that both can be presented at the coming Annual Meeting.

One report is that of the Power Test Committee which was published in preliminary form in The Journal nearly two years ago. Since then the report has been thoroughly revised and is now being put into its final form. It attempts to standardize the methods of testing the various types of prime movers and auxiliary apparatus, and is so broad in its scope that it will interest a very large number of members of the Society, and it is expected will constitute one of the most comprehensive publications that the Society has ever issued.

The other report, that of the Committee on Standardization of Steam Boilers, is equally voluminous, and is also approaching its completed state, as recounted elsewhere in this number of The Journal. Its value both to engineers and the public at large is so great that it can scarcely be estimated, involving as it does every item of consequence in relation to the safety of steam boilers, from the specifications of steel to the qualifications of the men in the boiler room.

An interesting session, in charge of the sub-committee on Iron and Steel, will be devoted to subjects relating to Cast Iron and Steel from the standpoint of the mechanical engineer. New developments in the field of engineering metals will be dealt with in a way to bring out and make a matter of common knowledge these recent advances. Other sessions in charge of sub-committees will be those on Machine Shop Practice and on Railroads. At the latter there will be a report by the sub-committee on Railroads, on the Steam Locomotive of Today. Copies of individual papers have been received from other sub-committees, and one session will be devoted to a number of miscellaneous papers of exceptional merit. The subjects of these will be announced in The Journal for November, when the complete program for the meeting will be published together with abstracts of such papers as are to be printed in advance of the meeting.

As has been the custom for some years past, the President's Reception will be given on Tuesday evening during the convention, and on Wednesday evening there will be a lecture upon a subject to be announced. The reunion this year is expected to take the form of a dinner dance at the Hotel Astor, and this will constitute the chief social event of the meeting. Covers will be laid for at least 350, and there will be dancing between courses. The grand ball room at the Astor has been engaged for this occasion.

LOCAL MEETINGS

A number of meetings in local centers are announced for October and are evidence of the renewed activities of the committees in charge. In several cities, for example in Buffalo, as reported in the September issue of The Journal, plans have already been made for the entire season, including subjects and speakers.

A joint meeting with the Franklin Institute will be held in Philadelphia on October 8, with a paper to be presented by J. E. Johnson, Jr., of New York, on Recent Development in Cast-Iron Manufacture. Mr. Johnson will discuss the present theory of cast iron, explaining its deficiencies and pointing out the unknown or neglected quantities which cause them. He will connect the completed explanation with the known facts of practice in regard to coke and charcoal irons and describe the method for converting ordinary coke iron into a product superior to the best charcoal iron at low expense. Samples of the converted material will be shown, together with photomicrographs of its structure. The lecture will be illustrated with lantern slides.

The meeting in Cincinnati, on October 15, will also be a joint meeting, in this instance with the Engineers Club, and Prof. F. R. Hutton will be the speaker of the evening. His subject will be the Testing of the Motor Vehicle Engine, and the address will be illustrated by lantern slides. The Engineers Club will as usual be the meeting place.

Charles Whiting Baker will address the Buffalo meeting on October 22, taking up the timely subject of the Engineer and Public Service; and the St. Paul membership will discuss the paper by Adolph F. Meyer, Power Developments on the Mississippi River between St. Paul and Minneapolis, on October 22. Meetings will also be held in New York and Boston, but neither date has as yet been announced. The Boston meeting will take up the subject of Flow Meters.

CURRENT AFFAIRS

Notwithstanding the fact that any discussion of financial matters may give some the impression of unsound conditions, we are glad to take this opportunity to emphasize a contrary state of affairs.

Our Society is one of the strongest financially in the world. We have assets amounting to considerably over a half-million dollars. These include principally a one-third interest in the property of the United Engineering Society; all the trust funds, amounting to over $40,000, which are invested in non-taxable bonds; and about $30,000 in cash and stores. In addition to dues, there has also been an income for a number of years from advertising in The Journal.

We have, furthermore, financed our small indebtedness, $60,000, on the land occupied by our building, by issuing certificates of indebtedness, as it was considered just to distribute the payment over a period of years. The Society has pledged itself to retire these certificates at the rate of $6000 per year. As an earnest of this promise and offsetting the indebtedness, we have $24,000 in a special fund, all invested, so that there are, in other words, four years' payments in hand now. This is not, however, available to be used for current expenses.

On account of the conditions prevailing in the world generally, the Finance Committee feel that the program for the year should be conservative. In the first place, there will be an absolute shrinkage in dues, and, second, the income from publications will be less; so, that, together with a probable reduced income from miscellaneous sources our total income will be $15,000 less than it would be under favorable conditions. Because, therefore, of the reduced income and the restrictions of the Finance Committee, all the Society's activities must share in reduced appropriations.

One of the phases of the work considered by the Council to be of fundamental interest and benefit to the membership, is the holding of meetings in the various cities. Wherever a slight curtailment in appropriations for these meetings shall prove necessary, it is hoped that the local committees will realize that it is not because of lack of interest nor of financial unsoundness in the Society's affairs.

ANNUAL MEETING

The program for the Annual Meeting promises to be one of the most interesting the Society has ever enjoyed. Special emphasis should be laid upon the all-day session of December 3, devoted to Public Service. This is in line with the efforts of the Society to interest the engineer to a greater extent in civic affairs, as well as to bring to the attention of the public the place he should occupy in such affairs.

COMMITTEE REPORTS

Among the reports which will come before the Annual Meeting for final discussion and which promise to promote great interest are those on Power Tests and Boiler Specifications.

With regard to the latter, during the month past a very widely attended public hearing has been held, lasting several days, which has resulted in unanimity on the part of all boiler interests in America and the interests which manufacture the materials that go into the boiler. The importance of this code lies in its relation to pending legislation. Some members of the Society have opposed the code because it does involve legislation, but the whole trend of the times is toward the establishing of our laws respecting materials upon a good engineering basis rather than allowing them to be framed by men untrained in technical matters.

INTERNATIONAL ENGINEERING CONGRESS

The five societies acting as hosts of the International Engineering Congress have formed a joint reception committee, consisting of Alex. C. Humphreys, chairman, Walter M. McFarland, vice-chairman, Charles Warren Hunt, secretary, William L. Saunders, treasurer, Wm. H. Wiley, Eben E. Olcott, George F. Kunz, Bradley Stoughton, E. D. Meier, Ambrose Swasey, Calvin W. Rice, Howel H. Barnes, Jr., George F. Sever, F. L. Hutchinson, Stevenson Taylor and Daniel H. Cox.

George M. Brill, a member of the American Institute of Electrical Engineers and of our Society, has been appointed director, with headquarters in the Engineering Societies Building. Mr. Brill will organize, under the auspices of this general committee, reception committees in each of the big cities of the union. These reception committees will be representative of all that is best in civic life as well as in the engineering field.

Although it is reasonable to expect that the war in Europe will interfere with the original plans of the Congress, letters from officials of the Congress and also from the Verein deutscher Ingenieure indicate that they are going ahead with their arrangements.

RELATIONS WITH SOUTH AMERICA

The present situation seems to offer an opportunity to develop our cultural relations with South America through the medium of the Panama-Pacific Exposition and the Engineering Congress. The Secretary of the Society has been active for a number of years in trying to promote these relations. This year, for the first time, he has succeeded, and the United States has issued through its State Department the necessary formal invitations to the Governments of Central and South America, to attend a Pan-American Scientific Congress, to be held in Washington in October 1915. It is expected that the national engineering societies will be invited to assist the Government in the conduct of this congress.

Calvin W. Rice, *Secretary*

REPORT OF THE NOMINATING COMMITTEE

To James Hartness, President of The American Society of Mechanical Engineers:

Your committee appointed to nominate officers for the ensuing year has completed its work and herewith submits its report:

Your committee departed from the custom followed in the Society for some years, of sending a circular letter to the entire membership inviting suggestions as to the nominees. Experience has shown that only a small percentage of the membership, less than one-sixth in any one year, make any reply to these circulars. Most of those who do reply, moreover, send merely off-hand suggestions. It is not to be expected that an individual member will give the time, thought and study to the various questions in connection with the nominations that is essential if wise choices are to be made.

Further than this, because so few members take the trouble to answer the circular letter, the opportunity is open for any member or group of members to send out letters asking that a particular candidate be recommended to the Nominating Committee, with the result that that committee may be flooded with what is apparently an overwhelming and spontaneous demand from the membership that this candidate's name should be placed upon the ticket.

For these and other reasons, your Nominating Committee believed it desirable that a departure be made from the custom of sending out a general invitation to the membership for suggestions. It is to be remembered that the procedure from which we have departed this year is a mere custom introduced by an earlier Nominating Committee. It is neither required nor authorized by our Constitution and By-Laws, and former committees which have followed that method have done so in the exercise of the discretion vested in them; just as the present committee has thought best to abandon the custom this year.

But there is no doubt that your committee and any nominating committee, needs aid and advice from outside its own membership in order to make a wise selection of candidates. The members of the committee, therefore, conferred individually with and asked the advice of various members of the Society, selecting those who were known to be especially interested in the Society's work and willing to take time to give careful thought to matters affecting its welfare. Personal letters were also sent by the members of the committee to members of the Society representative of different branches of the profession and resident in different parts of the country, in order to make the advice thus obtained truly representative of all sections of the membership.

From the results we have obtained, we believe this system of seeking advice from members, each of whom is requested to give careful thought to the matter, affords a far safer, more constructive and more discriminating aid to a nominating committee than the old plan of a printed circular letter sent broadcast to the entire membership.

The only embarrassment your committee has experienced has been from the number of well-qualified candidates for the various offices presented for our consideration. In making our selection we have been governed not alone by the ability of the candidates to render useful service to the Society and their prominence in the profession, which makes the nomination deserved, but by the propriety of giving due representation in the Council to different geographical sections and also to different branches of the profession.

In presenting the candidates we have chosen, moreover, we present also a brief summary of their respective professional careers, for the benefit of those members who may not know them personally. This seems to us essential to enable members to judge intelligently in casting their letter ballot in the election.

The candidates we now present are as follows:

For President:
Dr. John A. Brashear, Pittsburgh
For Vice-Presidents:
Henry Hess, Philadelphia
Geo. W. Dickie, San Francisco
James E. Sague, Poughkeepsie
For Managers:
Charles T. Main, Boston
Spencer Miller, New York City
Max Toltz, St. Paul
and to fill the unexpired term of the late Alfred Noble:
Morris L. Cooke, Philadelphia
For Treasurer:
Wm. H. Wiley, New York City

Respectfully submitted,

John E. Sweet, *Chmn.*
Charles Whiting Baker, *V-Chmn.*
John H. Barr
A. M. Hunt
P. W. Gates
Nominating Committee

An account of the professional career of each of the nominees follows:

JOHN A. BRASHEAR

John A. Brashear was born in Brownsville, Pa., in 1840 and educated in the public schools. He learned the machinist's trade and from 1860-1870 worked in the rolling mills of Pittsburgh. The study of astronomy, however, had been his hobby from boyhood, and all his spare time was devoted to it. In 1870 he attracted the attention of Langley, then head of the Allegheny Observatory, and through the assistance of Mr. William Thaw, one of the observatory patrons, set up a shop in Allegheny for the manufacture of astronomical instruments. In a very short time he became widely known as an expert in the development and manufacture of astronomical instruments of precision, and it is safe to say that a history of the work of his shop would closely approximate the history of astronomy during the last thirty years.

Perhaps his most important achievement has been in connection with the design and development of the spectroscope for astronomical uses, particularly with reference to the mechanical features. In 1888 he completed the spectroscope for the 36-inch telescope of the Lick Observatory, furnishing the mechanical parts, and at the same time a complete small spectroscope, including the prisms and all other optical parts. The excellence of the work which has been done by Professor Keeler at the Lick Observatory is freely attributed to Dr. Brashear's skill and genius, and many of the spectroscopes from the principal observatories of the world have been sent to Dr. Brashear to be remodeled.

Dr. Brashear's more purely scientific work also brought recognition and about the time of his removal to Allegheny he was given an appointment in the University of Western Pennsylvania of which the Allegheny Observatory was a department. From 1898 to 1900 he was acting director of the Allegheny Observatory and has always kept in touch with its development, and through his efforts it has been put in every possible way at the disposal of the public. For a number of years past Dr. Brashear has also been a trustee of the Carnegie Institute of Technology, and it is said that he has done more for the cause of education in Pittsburgh than any three other men. Several years ago a friend placed in his hands an endowment fund of $250,000, to be used for the advancement of the public schools, as a result of which 600 teachers have been sent to different parts of the country for rest and study, bringing back with them new ideas and greater enthusiasm.

Dr. Brashear is a fellow of the American Association for the Advancement of Science and the Royal Astronomical Society of Great Britain; is a past-president of the Engineers Society of Western Pennsylvania and the Pittsburgh Academy of Arts and Sciences; and is a member of the British Astronomical Association, the Société Astronomique de France, the Société de Belgique, the American Philosophical Society, the Astrophysical Society of America, the National Geographic Society, and an Honorary Member of the Royal Astronomical Society of Canada. He has been honored with the degree of LL.D. by Washington and Jefferson College and by Wooster University, and with the degree of Sc.D. by Princeton University and the Western University of Pennsylvania. He was made an Honorary Member of this Society in 1908.

HENRY HESS

Henry Hess was born in Darmstadt, Germany, in 1863, coming to the United States shortly thereafter. He received his education in the New York schools, with several additional years of schooling in Germany. He began his professional career upon his return to the United States in 1880, working successively as machinist, draftsman, designer and superintendent, among others with the Pond Machine Tool Company, Worcester and Plainfield, the Watervliet Arsenal, U. S. A., on the design of special heavy ordnance machine tools, the Niles Tool Works Company, the Bureau of Construction and Repair, U. S. N., and spent several years in Germany as consulting engineer and later managing director of the German Niles Tool Works Company of Berlin. In 1904 he founded The Hess-Bright Manufacturing Company, inaugurating the American heavy ball bearing industry. He disposed of these interests in 1912 and formed The Hess Steel Castings Company and The Hess-Ives Company.

Mr. Hess is past-president of the Society of Automobile Engineers and of the Engineers Club of Philadelphia, and is a member of the American Institute of Mining Engineers, the American and International Societies for Testing Materials, the American Electrochemical Society, the Verein deutscher Ingenieure, the Institute of Automobile Engineers of Great Britain, and a life member of the Schiffbautechnische Gesellschaft. He has been an occasional contributor to various technical publications as well as to the Transactions of the various organizations to which he belongs.

G. W. DICKIE

G. W. Dickie was born in Arbroath, Scotland, July 17, 1844, and was educated at Tayport, Fife. From 1860 to 1864

he served a special apprenticeship in the locomotive and marine shops of the Edinburgh, Perth and Dundee Railway, now known as the North British Railway, serving an additional two years in the construction of spinning mill machinery at Monifieth, Scotland. He was employed in the shipyard of Wm. Dickie & Sons, Tayport, Scotland, from 1866 to 1869.

In 1869 Mr. Dickie came to the United States and was employed as an engineer for the Risdon Iron Works of San Francisco, where besides having charge of their marine work he took a leading part in the design and construction of the heavy machinery for the Comstock Mines. He subsequently became engineer-in-chief of the Risdon Iron Works and remained in their employ until 1883, when he became director and manager of the newly formed Union Iron Works Company. During his connection with this company twenty-three war vessels and about sixty merchant vessels were built, in addition to other large undertakings.

Since 1905 Mr. Dickie has been engaged in consulting work, for the most part in connection with marine engineering and naval architecture in San Francisco. He superintended the building of the steamer President at the yard of the New York Shipbuilding Company, and the design and construction of the steamers Governor and Congress.

JAMES E. SAGUE

James E. Sague was born at Poughkeepsie, N. Y., July 20, 1862. He is a graduate of the Stevens Institute of Technology. His thesis, a Report on the Trial of the Steamer City of Fall River, was published in the American Engineer and the Journal of the Franklin Institute. From 1883-1891 he was engaged in railroad work, acting successively as draftsman, engineer of tests, general shop foreman, and master mechanic. He then engaged in locomotive building, first with the Schenectady Locomotive Works and later with the American Locomotive Company, first as mechanical engineer, and later as assistant vice-president and vice-president, having charge of engineering and manufacturing.

When the public utilities of New York were placed under the control of Public Service Commissions in the first administration of Governor Hughes, Mr. Sague was appointed a member of the commission for the Second District, controlling all public utilities in New York State outside of New York City. He is the only engineer who has been appointed on the New York Commissions and has held the office for seven years.

CHARLES T. MAIN

Charles T. Main was graduated from the Massachusetts Institute of Technology in 1876 and remained as assistant in the department of mechanical engineering until 1879. He was for several years draftsman of the Manchester Mills, Manchester, N. H., and subsequently acted as engineer, assistant superintendent and superintendent of the Lower Pacific Mills, Lawrence, Mass. In 1892 he entered into consulting practice with F. W. Dean under the firm name of Dean & Main. Since 1907 he has been practicing under his own name, with offices in Boston.

Mr. Main has designed and supervised the construction of many industrial plants, also steam power and water plants, and has done a large amount of expert work, such as consultation, reports on various projects, valuations and on cases as a witness or referee. He is a past-president of the Boston Society of Civil Engineers, a term member of the Corporation of the Massachusetts Institute of Technology, and is now president of the Engineers Club of Boston.

SPENCER MILLER

Spencer Miller was born in Waukegan, Ill., in 1859, and was educated at the Worcester Polytechnic Institute, graduating in 1879. He entered the employ of the Link-Belt Company, Chicago, and while here designed a number of rope drives and apparatus for handling cargo from steamships, which is still in use in Chicago. He also devised a method of equalizing the grip of the ropes on the pulleys of different diameters by varying the angles of the grooves.

He has been for 26 years associated with the Lidgerwood Manufacturing Company of New York. At the time of his first connection with them the company had just begun to manufacture overhead cableway systems employing the crude chain connected fall rope carriers. Mr. Miller developed an entirely new system known as the button stop fall rope carrier system, which has been employed in the construction of U. S. fortifications, dams, filtration beds, sewers, open pit mining, and the Gatun Locks of the Panama Canal. He also perfected a system for log skidding by steam in the form of a cableway.

During the Spanish-American War he developed the marine cableway in solution of the problem of coaling at sea, and this has been used in the navies of Great Britain, Japan, Russia and Italy as well as the United States. The marine transfer for broadside coaling of ships in harbors is also one of his inventions. His most recent contribution is an automatic tension engine which makes it possible to operate a breeches buoy apparatus between two ships in the heaviest sea.

Mr. Miller is a member of the American Society of Civil Engineers, the Society of Naval Architects and Marine Engineers, the American Institute of Mining Engineers, and the Canadian Institute of Mining Engineers.

MAX TOLTZ

Max Toltz was born in Coeslin, Germany, in 1857, and was graduated from the Royal Polytechnical College of Berlin in 1878. He came to the United States in 1882 and became associated with the St. Paul, Minneapolis & Manitoba Railway, now the Great Northern, serving successively as draftsman, assistant engineer, bridge engineer, and mechanical engineer. In the latter capacity he had charge for four years of the motive power department.

From 1903 to 1905 he acted as consulting engineer of the Canadian Pacific Railway, during which time he built the Angus Shops near Montreal and also those at Winnipeg. He also acted as consulting engineer for the Erie Railroad at this period. In 1905 he became vice-president and general manager of the Manistee & Grand Rapids Railway, acting also as consulting engineer for different railroads at the same time. Since 1908 he has conducted a private practice, including the work of consulting engineer for the Great Northern Railway, the Northern Pacific Railway, the Chicago, Michigan & St. Paul and the Butte & Anaconda Railway, reporting especially upon the electrification of steam roads, and also specializing in power plants, grain elevators and large handling plants, and iron ore docks.

MORRIS L. COOKE

Morris L. Cooke was born May 11, 1872, in Carlisle, Pa., and received his education at Lehigh University, from which he was graduated with the degree of M.E. in 1895. He served an apprenticeship in the machine shop at Cramps Shipyard, Philadelphia, and later worked as journeyman machinist at the Southwark Foundry, Philadelphia. In 1896 he became engineer for the Acetylene Company, Washington, D. C., and in 1898 assistant engineer in the United States Navy, serving as engineer watch officer on the U. S. S. Miantonomoh and chief engineer on the U. S. S. Eagle during the war with Spain. Following the war he engaged in commercial organization work and since 1905 has acted as consulting engineer on matters of management, specializing in printing and the allied trades. Mr. Cooke conducted an inquiry on collegiate administrative methods for the Carnegie Foundation and the report has been issued under the title, Academic and Industrial Efficiency. Mr. Cooke is at present Director of Public Works for the city of Philadelphia.

WM. H. WILEY

Wm. H. Wiley was born July 10, 1842, in New York City, and received his A.B. degree from the College of the City of New York in 1861, and the degree of C.E. from Rensselaer Polytechnic Institute in 1866. He also studied as a special student at the Columbia School of Mines in 1868.

At the outbreak of the Civil War he joined the Seventh Regiment of New York Volunteers, and in 1862 was made first lieutenant. When the regiment was mustered out in 1864 he was given the title of Major U. S. V.

Since 1876 Major Wiley has been a publisher of scientific works. He served as a member of the 58th, 59th and 61st congresses, from New Jersey. In 1897 he was president of the International Jury of the Brussels Exposition, and was a member of the Superior Jury, Brussels. He was a commissioner from New Jersey at the St. Louis Exposition in 1904.

Major Wiley is the author of a book on Yosemite, Alaska, and Yellowstone, published in 1888, and has acted as New York correspondent for London Engineering. He is a member of the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, the American Association for the Advancement of Science, the National Geographic Society, the Order of Leopold, Belgium, and the Loyal Legion.

ALFRED FERNANDEZ YARROW ELECTED HONORARY MEMBER

At the meeting of the Council in July, Alfred Fernandez Yarrow of Blaneford, Stirlingshire, Scotland, was elected to Honorary Membership. Mr. Yarrow is known as one of the most eminent marine engineers, having been among the earliest to enter the field of construction of light, high-speed launches and torpedo boats. He is also noted for the scientific solution of the reduction of vibration in reciprocating engines. He, with the late Dr. Schlick, was the inventor of the method of balancing engines known as the Yarrow-Schlick-Tweedy system, which for almost twenty years past has been applied to large reciprocating engines in high grade ships. He was also a pioneer in experimentation on the subject of circulation in boilers.

Mr. Yarrow has done much in the line of improvements in machinery and hulls. He is also a leader in the educational field, particularly that of arranging for part time in college and part time in shop work. He presented to the British nation the experimental tank at the National Physical Laboratory, which is about 150 feet long by 50 feet wide, and is fully equipped with overhead running trolleys for the making of all manner of experiments in connection with marine design. He has also for many years maintained a marine hospital and sanitarium at his own expense.

He is a member of the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Institution of Naval Architects and Marine Engineers, and a member of the General Board of the National Physical Laboratory.

THE PUBLIC HEARING OF THE BOILER SPECIFICATIONS COMMITTEE

Held September 15, 1914 in the Rooms of the Society

The public hearing held September 15 and 16, 1914, by the Boiler Specifications Committee has been successful in clearing up many of the important features of the problem that had been in question.

As announced in the September issue of The Journal, further criticisms and suggestions had been requested from all who had not previously sent in a statement or who wished to make additional recommendations, and a wide and general response was received, covering the subjects in question so comprehensively and completely that much was accomplished at the hearing. The ready response and the general spirit of coöperation in evidence at the hearing afforded the committee much satisfaction. The ground covered was so extensive that it is the committee's expectation that its preliminary report may soon be completed.

As previously stated, the tentative draft of the committee's report, which had been printed in limited edition and issued to authorities on boiler subjects, was merely a suggested form to serve as a basis of study and criticism, and it is now being revised and rewritten to incorporate the various suggestions and recommendations received. It had been formulated with the boiler code of the State of Massachusetts as a foundation; these rules in general have already been adopted and successfully applied in the State of Ohio, the City of Detroit, and elsewhere, and thus carry the endorsement of actual application and use. When the demand arose for a code to be introduced into other states, it was naturally the desire that it be based upon the Massachusetts Code with such modifications and additions as were necessary to render it complete and up-to-date in every particular. To accomplish this, the committee has

concentrated its effort for over two years and has endeavored to render its proposed code a standard of the highest order and effective for maximum protection to life and property.

The hearing was the result of a resolution passed at the Spring Meeting of 1914 at St. Paul-Minneapolis, at which was felt the advisability of special meetings to grant all those interested the opportunity of discussing the many details of the problem, and to secure in this manner the best possible adjustment of differences that might arise. The far-reaching effect of some of the important elements of the new code was shown by the great amount of interest taken in the preliminary discussion at St. Paul and the need of much careful study revealed. The date of the hearing was set for September 15, and the meeting was called to order by the Chairman, John A. Stevens, in the auditorium on the fifth floor at 10.30 a.m. There were about 150 in attendance, including representatives from a number of organizations and engineering associations, from manufacturers of boilers and their constituent parts, from the boiler insurance companies and from legislative bodies in many states. Six members of the Boiler Specifications Committee were present as follows: John A. Stevens, Chairman, Wm. H. Boehm, R. C. Carpenter, Richard Hammond, C. L. Huston, and E. F. Miller.

The Chairman, Mr. Stevens, in calling the meeting to order, drew attention to the large number of boiler explosions that have occurred in this country with attendant fatalities and injuries, and expressed forcibly the necessity for better boilers and better conditions governing their operation to prevent this loss of life and property. The committee pointed out that this could be accomplished only by the introduction of uniform boiler laws in all states of the Union and their uniform enforcement. Referring to his experience as a member of the Massachusetts Board of Boiler Rules in formulating and introducing the first comprehensive and complete Code of Boiler Rules established in this country, he explained that the causes of this legislation lay not only in the many serious boiler explosions which had occurred at Brockton, Lynn, and elsewhere shortly before, but also in the difficulties resulting from lack of uniformity in the requirements of the various state inspectors. The committee showed that not only the manufacturers, but also the users of boilers deserve some freedom from the annoyances attending lack of uniformity among the many boiler inspectors in charge of the state inspections. Prior to the inauguration of the Code of Boiler Rules, where there were from 10 to 15 inspectors, there were 10 to 15 boiler laws. It was to avoid this confusion that the Boiler Code was formulated and similarly it now becomes a national duty to prevent confusion among the various states of the Union by formulating first a satisfactory Code of Boiler Rules and second, putting it into effect uniformly throughout every state.

Mr. Stevens stated that it was the policy and desire of the committee to receive and consider any and all suggestions for the Code that would make for greater protection of human life and property, and although the committee having scoured the country to obtain everything that would be of value for their report, considered that it had done its best, further suggestions and criticisms were expected and would be gladly received. The committee wished it to be understood that any features of the report that proved objectionable would be changed or omitted, but they desired to impress the fact that boilers can be properly built for any condition of operation and for almost any pressure for an increase of only 10 to 20 per cent in cost. They emphasized the fact that good boilers can and should be provided for by this Code.

The Chairman then introduced Edw. H. Wells, President of the Babcock & Wilcox Company, who spoke on the situation from the standpoint of the boiler manufacturer. He expressed himself as heartily in accord with the movement for standard specifications for steam boilers, first because he hoped that it might lead to the building of better and safer steam boilers, and second, because he hoped it might lead to uniformity in boiler laws throughout all states of the Union and thus eliminate much trouble and annoyance for the boiler manufacturers. He believed that this work must be done because it was inevitable, and that The American Society of Mechanical Engineers was the association that must do it. He bespoke for the committee the hearty support of the boiler makers, the boiler users, the manufacturers supplying boiler materials, the boiler insurance companies and all who were interested directly or indirectly in the subject.

Thos. E. Durban was then called upon and expressed his hearty approval of the committee's action in formulating the Code of Boiler Rules. He referred to the difficulties which he had experienced in connection with his work as chairman of the committee of the National Tubular Boiler Manufacturers Association in agitating the matter of uniform boiler laws. He showed the far-reaching effect of the present lack of uniformity and expressed the opinion that uniformity among the state boiler laws was an absolute necessity. He urged also the necessity for immediate action in this matter and pointed out the fact that five states are now preparing to enact legislation of this character.

Among the others who addressed the meeting were L. E. Connolly and W. H. Broderick representing the American Boiler Manufacturers Association, F. R. Lowell, Chas. S. Blake, Alex. C. Humphreys, E. T. Child, I. E. Moultrop, E. B. Katte, Edgar Marburg and C. D. Young.

The hearing first took the form of a discussion of methods of procedure in order to satisfy all inquirers and give every one interested an opportunity to be heard. After considerable discussion, it was decided

to take up all written discussions first, giving others the opportunity to be heard afterward. It was subsequently ruled that another public hearing should be held if the results of this demonstrated the need thereof, and that the committee should sit in conference with any interested body and give the representatives of that body opportunity for full discussion and consideration of every question involved by the report.

After the noon recess, the discussion of the Code was taken up systematically beginning with the first page of the pamphlet. The suggestions offered in writing had been classified with respect to their references to each page of the pamphlet and the work of considering the various recommendations was thus greatly facilitated. The early part of the afternoon was given up to the discussion of the engineers and firemen's license law and the boiler inspection law. The latter was considered from the standpoint of the users and operators as well as also of the insurance companies and the boiler manufacturers, and the question of the Boiler Control Boards that would become necessary in the various states discussed. Following this, Parts I and II of the Code were taken up and certain of the requirements discussed at length; among these were such items as boiler ratings, shearing strengths of rivets, factors of safety, the length of life of lap-seamed boilers, the safety valve formula, the question of safety valves on superheaters, fusible plugs, bracing of heads, etc.

The discussion upon safety valves occupied a considerable portion of the afternoon but was finally discontinued to enable a delegation from the National Association of Thresher Manufacturers to be heard. This committee favored a continuation of the O. G. type of flange on boilers under 50-h.p. nominal rating. Following this, a committee of the American Society of Heating and Ventilating Engineers was heard, and then the meeting was thrown open to the discussion of the question of boiler material; this discussion was continued without recess until the adjournment at 8.30 p.m.

The feature of the second day of the hearing, September 16, was a number of conferences with representatives of different associations which were undertaken by the committee in order to better enable them to determine the specific requirements of the industries affected. The first group to be heard was representatives of the lap-welded tube interests, who objected to the discrimination resulting from certain features of the report affecting the use of lap-welded tubes in boilers. As they, however, had no constructive criticism to offer, not having had an opportunity to meet and prepare their recommendations, it was arranged that their hearing be adjourned until September 26 to give them an opportunity to meet and prepare a complete specification for boiler tubes that should be satisfactory to all interests involved.

A committee composed of the representatives of the American Boiler Manufacturers Association and the National Tubular Boiler Manufacturers Association conducted a private meeting that lasted throughout the day of September 16, in which the preliminary report was discussed from all standpoints and very carefully considered for its application to the boiler manufacturing industry. The result of their work was a comment on the specification for boiler material suggested by the Association of American Steel Manufacturers, some further criticisms of the details of the report and finally the formation of a permanent organization for the purpose of taking definite action for the introduction of the Code after its acceptance by the Society, into the legislatures of the various states. This meeting was finally adjourned until Tuesday, September 29, on which date a general meeting of boiler manufacturers was called at Pittsburgh, Pa., for the purpose of furthering the work initiated here.

On September 26, the committee representing the boiler tube interests met in second conference with the Boiler Specifications Committee and presented a complete specification that is proposed for boiler tubes, both lap-welded and seamless. Also a representative of the National Association of Master Steam and Hot Water Fitters appeared before the committee and expressed the approval of that Association of the committee's work and particularly the changes recommended by National Boiler and Radiator Manufacturers Association and the American Society of Heating and Ventilating Engineers. Following this, conferences were held with representatives of the railroad associations and the safety valve manufacturers, both of which were, however, adjourned to later dates at which specific recommendations yet to be formulated, will be presented.

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i.e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by advising the Secretary promptly of anyone whose eligibility for membership is in any way questioned. Members will be furnished with complete records of any candidate thus questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will

be balloted upon by the Council unless objection is received before October 10, 1914.

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Bache-Wiig, Olai, Ch. Engr. & Supt., Wausau Sulphate Fibre Co., Mosinee, Wis.
Bergman, Julius G., Ch. Draftsman, Arizona Copper Co., Ltd., Morenci, Ariz.
Blackburn, Wm. A., Asst. Genl. Foreman, Cadillac Motor Co., Detroit, Mich.
Blickman, John A., Asst. Supt., Section Switchboards and Detail Apparatus, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Brooks, Charles C., Asst. Western Mgr., Mead-Morrison Mfg. Co., Chicago, Ill.
Bruce, James M., Mgr. of Salesmen, Smoking Tobacco Dept., American Tobacco Co., New York
Brush, Alanson P., Cons. Engr., 203 Boyer Bldg., Detroit, Mich.
Burt, George R., Rep. & Cons. Engr., American & British Mfg. Co., Providence, R. I.
Case, Willard L., Secy. & Genl. Wks. Mgr., The Salt's Textile Mfg. Co., Bridgeport, Conn.
Champion, Albert, Genl. Mgr. & Vice-Pres., Champion Ignition Co., Flint, Mich.
Davis, George C., Pres., G. M. Davis Regulator Co., Chicago, Ill.
Dobyne, Stevenson A., Genl. Supt., Champion Shoe Machinery Co., St. Louis, Mo.
Eastwood, Everett O., Prof., Univ. of Washington, Seattle, Wash.
Foster, Frank A., Prof. of Engrg. & Freehand Drawing, Tangshan Engrg. College, Tangshan, North China
Gibson, Elmer E., Asst. Supt., Jones Speedometer Co., New Rochelle, N. Y.
Harris, George E., 60 Granger St., Buffalo, N. Y.
Johnson, Wm. B., Mech. Engr., Acme Wire Co., New Haven, Conn.
Luke, Wm. A., Mgr., The West Virginia Pulp & Paper Co., Covington, Va.
Lynch, Thomas M., Asst. Mgr., Buena Vista Extract Co., Buena Vista, Va.
McCandlish, Robert M., Pres., R. M. McCandlish Engrg. Co., Kansas City, Mo.
Miller, D. W., Rep. Engr., Minneapolis Steel & Mchy. Co., Minneapolis, Minn.
Misostow, Henry, Smoke Dept., City of Chicago, Chicago, Ill.
Monte, Robert A., Draftsman, Regina Co., Rahway, N. J.
Morris, W. Cullen, Engr. of Constr., Consolidated Gas Co. of N. Y., New York
Oakes, Ernest A., Developing Own Inventions, 184 W. Church St., Seymour, Conn.
Oakley, Clifford H., Pres., Essex Rubber Co., Inc., Trenton, N. J.
Pfeffer, John E., Vice-Pres., Continental Engrg. Co., Chicago, Ill.
Pook, C. H. O., with Canadian Westinghouse Co., Ltd., Hamilton, Canada
Richardson, Chas. F., Ch. Mech. Engr., The Taft-Peirce Mfg. Co., Woonsocket, R. I.
Schmitt, F. E., Assoc. Editor, "Engineering News," New York
Searby, Wm., Supt., Hawaiian Commercial & Sugar Co.'s Mills, Puunene, T. H.
Sloat, Halbert M., Rep., in Brazil, American Locomotive Co., Rio de Janeiro, Brazil
Smallbone, Harry E., Pres. & Supt., Smallbone Mfg. Co., Chicago, Ill.
Sulentic, Stanislaus A., Constr. Engr., The Prairie Oil & Gas Co., Independence, Kansas
Sullivan, Frank A., Ch. Draftsman, Ordnance Drawing Room, Bethlehem Steel Co., S. Bethlehem, Pa.
Sykes, Walter J., Head, Mech. Dept., Panama Pacific International Exposition, San Francisco, Cal.
Thompson, Burt D., Foreman, Mch. Shop, National Twist Drill & Tool Co., Detroit, Mich.
Wainwright, Arthur V., Vice-Pres. & Genl. Mgr., American Public Service Co., Abilene, Texas
Wells, David E., Mech. Engr., Milliken Bros., Inc., Mariners Harbor, N. Y.
Wilkinson, Clarence M., Engr. & Supt. of Constr. for M. C. Schwab, Cons. Engr., New York

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Bass, Willard J., Erecting Engr., Armour & Co., Chicago, Ill.
DeVisser, John H., Treas. & Sales Engr., The Coon-DeVisser Co., Detroit, Mich.
Earle, Frederic E., Pres. & Treas., F. E. Earle Co., New Bedford, Mass.
Elam, Arthur M., Charge of Drawing, Columbus Trade School, Columbus, Ohio
Ervin, John F., Foundry Expert, Deere & Co., Moline, Ill.
Graner, Adolf, Production Engr., Eisemann Magneto Co., Brooklyn, N. Y.
Hardman, Frederick J., Asst. Examiner, U. S. Patent Office, Washington, D. C.
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Illingsworth, George C., So. Rep., Murphy Iron Works, Detroit, Mich.
Koza, Albert H., Mgr., Statistical Dept., Goodyear Tire & Rubber Co., Akron, Ohio
Nibecker, Karl, Steam Engr., The Youngstown Sheet & Tube Co., Youngstown, Ohio
Sonn, George P., With Union Metallic Cartridge Co., Bridgeport, Conn.
Wolfgang, Wm. H., Designer, National Supply Co., Toledo, Ohio

FOR CONSIDERATION AS JUNIOR

Beranger, Joseph P., Ch. Engr., Central Ansonia Sugar Co., San Domingo, P. R.
Carter, Clifford R., Asst. Mgr., Standard Oil Co. of N. Y., Soochow, China
Chute, Stanley J., Asst. to Mech. Engr., Pennsylvania Coal & Coke Corp., New York
Cornwell, Hobart V., Asst. to Mech. Engr., Pennsylvania Coal & Coke Corp., New York
Dutcher, Charles H., Jr., Draftsman, Interborough Rapid Transit Co., New York
Foster, Robert J., Mech. Engr., Eberhard Faber Pencil Co., Brooklyn, N. Y.
Green, Harold L., Industrial Engr., C. H. Scovell & Co., Boston, Mass.
Hill, Rowland F., Ch. Draftsman, The National Supply Co., Toledo, Ohio
Hoffman, Roscoe C., Designing Engr. & Ch. Draftsman, Haynes Automobile Co., Kokomo, Ind.
Nigh, George W., Special Apprentice, Rock Island & Pacific Railroad, Des Moines, Iowa
Netherwood, Joseph S., Head Draftsman, Motive Power Dept., Sunset Central Lines, Houston, Texas
Ohmer, John F., Jr., Sales Dept., Ohmer Fare Register Co., Dayton, Ohio
Panuska, Frank C., Instr. of Industrial Arts, Teachers College, Columbia Univ., New York
Platt, Louis J., Industrial Gas Fuel Rep., Public Service Gas Co., Newark, N. J.
Rockwell, Sherburne B., Asst. Supt., International Silver Co., Waterbury, Conn.
Roesen, Robert H., With American Machine & Foundry Co., Brooklyn, N. Y.
Schubart, Frank H., Engr., Wheeler Condenser & Engrg. Co., Carteret, N. J.

Scott, Thomas W., Apprentice Gas Producer Erector, Smith Gas Pwr. Co., Lexington, Ohio

Terzian, Harutyun G., Cadet Engr., Gas Works, Syracuse Lighting Co., Syracuse, N. Y.

Waters, Everett O., Instr. in Mch. Design, S.S.S., Yale Univ., New Haven, Conn.

Welford, Percy G., Asst. to Wks. Mgr., Canada Mchy. Corp., Ltd., Galt, Ont., Canada

PROMOTION FROM ASSOCIATE

Dunkel, H. Edward, Draftsman, Semet-Solvay Co., Syracuse, N. Y.

PROMOTION FROM JUNIOR

Baker, Charles H., Mech. Engr., Public Service Elec. Co., Newark, N. J.

Hersey, Mayo D., Asst. Physicist, U. S. Bureau of Standards, Washington, D. C.

SUMMARY

New applications	75
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Promotion from Junior	2
	78

THE FRANKLIN MEDAL

The Franklin Medal, to be awarded in recognition of distinguished achievements in science and technology, has recently been founded by Samuel Insull, president of the Chicago Commonwealth Edison Company and a member of the Franklin Institute, by which it will be awarded. The medal will be of gold and the accepted design, by R. Tait McKenzie, shows a bust of Benjamin Franklin on the obverse side, and on the reverse side the words, "Awarded by the Franklin Institute for Signal Eminent Service in Science." It is the intention to show recognition of the total contributions of individuals to science or to the applications of physical science to industry, rather than of any single invention or discovery, however important.

KELVIN MEMORIAL AWARD

The Executive Committee of the Institution of Civil Engineers has under consideration the question of the disposal of the balance of the Kelvin Memorial Fund, now in their hands. The total sum received to the credit of this fund amounted to £1704, of which £1222 was expended in connection with the Kelvin Memorial Window placed in Westminster Abbey.

It has been recommended that this balance of £481 be applied to the establishment of a Kelvin Gold Medal, to be awarded triennally as a mark of distinction in engineering work or investigation, along the line of Lord Kelvin's own interests. The first award will probably be made in the spring of 1915.

SYMPOSIUM ON POWDERED FUEL

At the Spring Meeting, June, 1914, one Session was devoted to a Symposium on Pulverized Fuel at which three papers were presented upon different types of plants using pulverized fuel apparatus as follows: Pulverized Coal Burning in the Cement Industry, R. C. Carpenter, Pulverized Coal for Steam Making, F. R. Low, and An Installation for Powdered Coal Fuel in Industrial Furnaces, Wm. Dalton and W. S. Quigley. There was also a topical discussion upon the constructive and operative features of pulverized fuel plants.

PULVERIZED COAL BURNING IN THE CEMENT INDUSTRY

BY R. C. CARPENTER, ITHACA, N. Y.

Member of the Society

The process of burning powdered coal has been developed in but few arts and only in relation to certain types of furnaces. For more than 30 years various schemes for burning powdered coal in boiler furnaces have been suggested and numerous patents have been taken out on various processes and burners, but without any marked degree of success. In the Portland cement industry commercial success was attained more than 15 years ago as a result of a series of investigations and experiments. The furnace employed had much to do with the practical success which was finally attained, and for that reason its construction and mode of operation will be briefly described. This furnace is familiar to Portland cement engineers, but is not well known in the other arts.

Portland cement is manufactured from a mixture of materials containing lime and silica which are brought together in definite proportions to produce a chemical combination. The raw material is principally carbonate of lime, or limestone in some form, and clay or shale. The materials are pulverized raw and mixed in proper proportions. The raw mix is introduced into a kiln either in the form of a dry powder or in a wet and plastic condition where it is subjected to an extremely high temperature and in which the required chemical combinations take place. The material discharged from the kiln is known as cement clinker; it is pulverized in various forms of grinding mills and reduced to a powder so fine that 92 parts or more will pass through a sieve having 100 meshes to the linear inch. This paper has to do only with the combustion process which takes place in the kiln. In the early days of the art fixed kilns were employed, but at the present time the rotary kiln is almost universally used.

THE ROTARY KILN

The rotary kiln in its essential features was patented by Siemens in 1869 and, in combination with a gas burner and other appliances, by Ransome in 1885. It was not found successful in England for cement burning, but was adopted by the Atlas Company in America about 1890 and was improved and developed by that company and other American companies to such a degree that it practically replaced every other method of burning Portland cement.

The modern rotary cement kiln consists of a slightly inclined steel cylinder mounted on rollers and arranged so that it can be revolved. The upper end is connected to a stack or chimney for the escape of the discharge gases and is provided with means for supplying the raw cement material in the form of dust or slurry. At the lower end of the cylinder is a stationary hood which performs the function of affording a discharge opening for the burned material and which also acts as a support for the fuel supplying devices. The rotary cylinders are of various dimensions. The tendency has been continually to increase the size of the cylinder. Thus, for instance, in 1890 the rotary kilns were in some instances 4 ft. in external diameter and 40 ft. in length. From 1895 to 1902 the kiln dimensions were quite generally 6 ft. in diameter and 60 ft. long. At the present time kilns 10 ft. in diameter and 150 to 200 ft. long are common. The Atlas plant at Hudson is equipped with kilns 12 ft. in diameter and 232 ft. long. In most of the late installations the kilns are true cylinders having the same diameter at top and bottom, but in many plants kilns are to be found with the diameter at the top about one foot less than at the bottom, the two parts being connected by a tapered section.

The rotary kiln is lined throughout with a fire-brick lining, except in rare cases where a very wet slurry is employed, in which case the lining for a short distance from the upper end is omitted. The temperatures required in the combustion chamber for burning cement clinker are from 2800 to 3000 deg. fahr. To withstand the high temperature, a lining having high refractory qualities must be employed. It must also have the quality of withstanding decomposition by the chemical action taking place in the kiln. The problem of kiln linings is a very serious one since no lining has been found that will stand for a great length of time under the conditions of operation. The lower part especially has to be repaired frequently unless the conditions are unusually favorable. The kiln is operated so as to keep the lining coated with the cement mixture for the purpose of protection. The lining prob-

Presented at the Spring Meeting, at St. Paul-Minneapolis, 1914, of The American Society of Mechanical Engineers.

lem, except as it bears on the combustion of powdered fuel, has no place in this paper and will not be discussed further.

A diagram of a cement kiln in elevation and plan is shown in Fig. 1. This diagram shows the general features and the arrangement of the various operating parts with reference to each other. In the diagram the rotary kiln is shown at *C*, the flue for discharge gases at *B*, the supporting rolls at *DD*, the stationary hood at the lower end at *E*, the rotary clinker cooler at *G*, the clinker pit at *F*, the blower for supplying compressed air at *H*, the coal bin at *K*, the feeding injector for coal dust at *J*, the conveyor for delivering coal to the fuel tank at *L*, the dust bin for raw material at *A*, and the kiln stack at *S*. The hood *E* is usually mounted on rolls so as to be easily moved for repairing of the kiln. It is customary to supply a separate stack for each kiln, although in some cases one stack receives the discharge from two kilns. In a large installation it is customary also to supply the air for several burners with one blower. In the installation shown in Fig. 1 the blower draws in air which has been warmed by passing through a rotary clinker cooler.

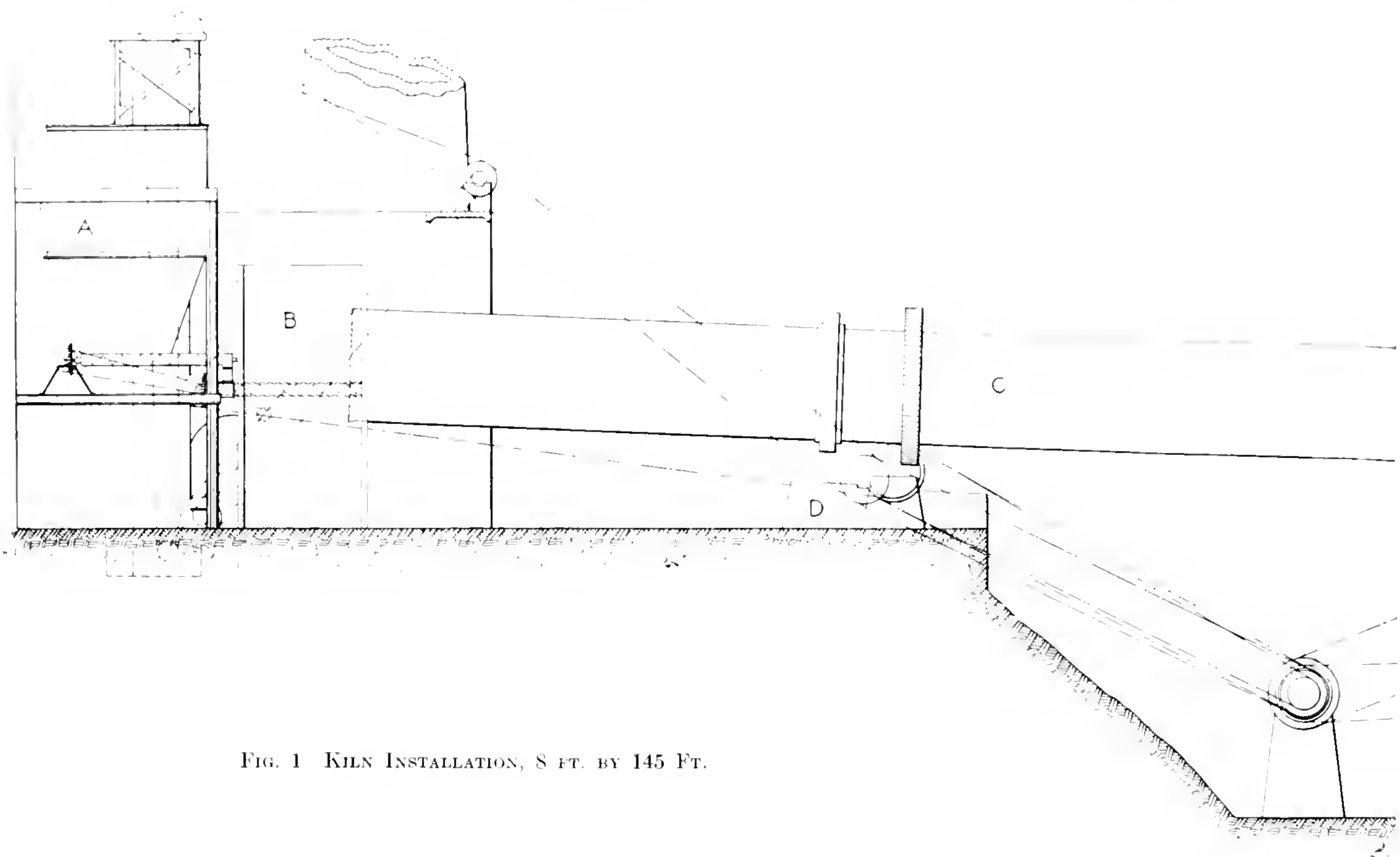


Fig. 1 Kiln Installation, 8 ft. by 145 Ft.

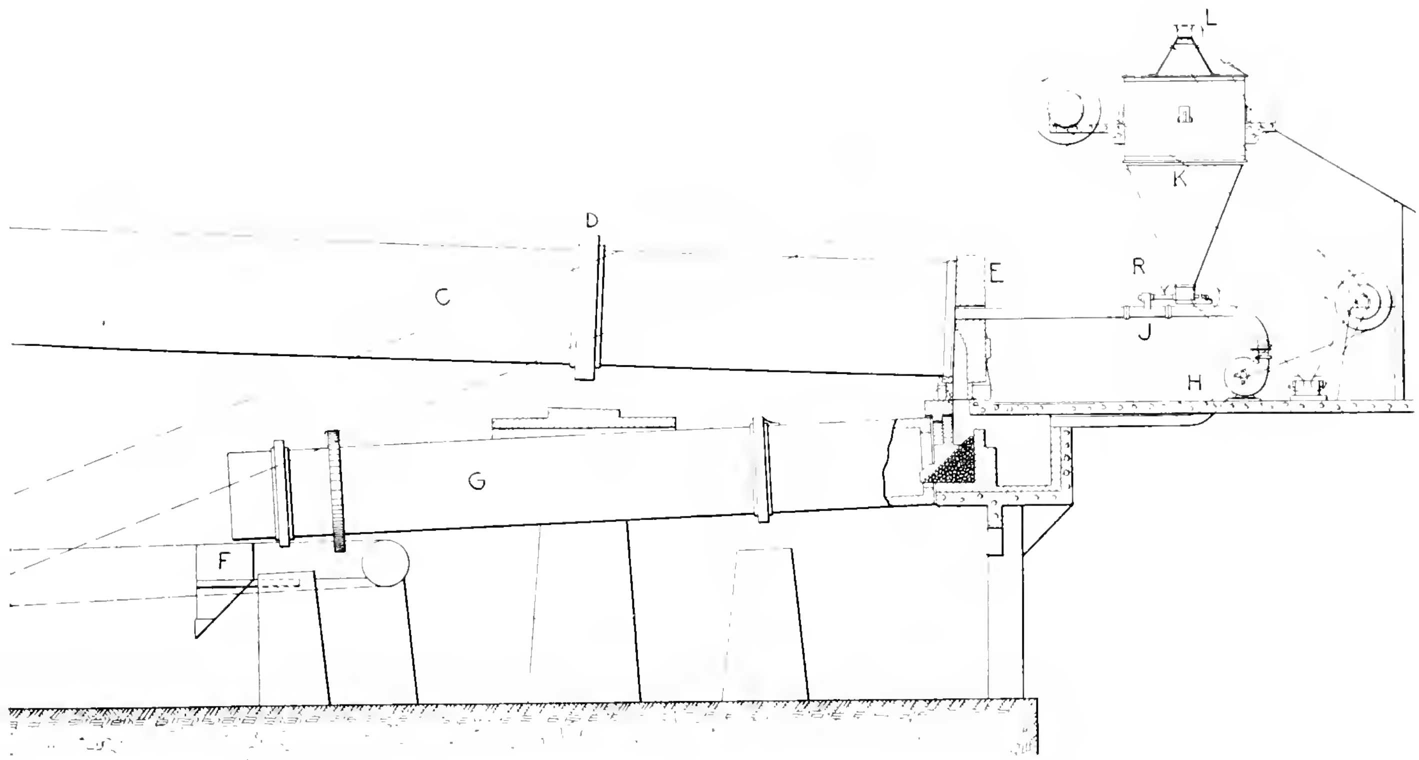
DEVELOPMENT OF THE BURNING PROCESS

During the early years of the Portland cement industry in this country, oil was employed as a fuel. This was sprayed into the lower end of the furnace with a jet of compressed air or steam. The oil was employed successfully, but due to the increasing cost after 1895 its use was very expensive. From 1897 to 1900, the increase in price was such as to make the use of oil nearly prohibitive from a commercial standpoint, and was the principal incentive for developing the use of pulverized coal.

In 1894, a series of experiments relating to the use of pulverized coal were started by the Atlas Company, in charge of Messrs. Hurry & Seaman, chief engineer and superintendent respectively. These experiments led to many discoveries, the invention of various parts, and finally to the commercial development of the art. Hurry & Seaman are entitled to the credit of the first successful use of powdered coal in the cement industry. This use was begun in 1895 by the Atlas Company and has never been discontinued. Other engineers along independent lines worked out the problem a few years later although possibly receiving some assistance from information disseminated throughout the industry relating to the results obtained by Hurry & Seaman. It may be stated that at the particular date referred to, every mill in the industry jealously guarded every detail of manufacture as a valuable trade secret, consequently little or no direct information as to details of process or machinery employed was common in the different mills. The information which leaked out at that time respecting details of operation or machinery was generally inaccurate and based on speculation or rumors. The success of the process of burning pulver-

ized coal in the Atlas plant was not generally known in other mills until about 1900 when the process was put in successful operation in various plants by independent investigators.

The art as at present developed consists of a process for delivering to the kiln the powdered fuel or fuel dust by a jet of air which impinges on the fuel dust in some type of injector with force enough to discharge the dust into the kiln. The process, with details of mechanism, is illustrated in Fig. 1 in relation to a kiln. Fig. 2 gives an idea of the character of the combustion which takes place in the burning of pulverized



fuel.[1] The compressed air may be obtained from a fan or compressor as may be more convenient; the diagrams indicate both schemes.

The injector varies greatly in different constructions but it performs the function of injecting the coal dust into the kiln by a jet of air and it does not handle sufficient air for combustion. The additional air needed for combustion enters the kiln principally through openings in the hood and through the discharge duct for clinker. Such openings are shown in Fig. 2 by arrows at points marked *a*. The amount of air supplied by the compressors or fans should be sufficient merely to carry the dust into the kiln without producing an explosive mixture. The fuel dust enters the combustion chamber of the kiln in the form of a black cloud and burns in the form of an elongated torch, as indicated by Fig. 2. The length of the flame in actual kiln constructions is generally from 25 to 40 ft., although this is affected by conditions. The diameter of the flame in some places may very nearly equal that of the combustion chamber. Under best conditions of burning the flame does not perceptibly impinge against the sides of walls of the kiln, and the heat utilized is practically all given off by radiation.

THE POWDERED FUEL PROBLEM

The problem is one of combustion under peculiar conditions. The burning of pulverized coal differs from the burning of solid fuel, from a theoretical standpoint, principally in one particular. In the combustion of coal of commercial sizes lying on the grate, the air for combustion passes between the pieces of coal and the products of combustion pass off in the flues. Coal dust does not burn under such conditions, as the particles are so fine that sufficient air for combustion does not reach the coal through the crevices between the particles. To burn powdered coal successfully, it must be burned while in suspension in the air. In such a position each particle is surrounded by air which supports the combustion. The form of the furnace used in the Portland cement art is favorable for combustion in suspension since it is very long and affords plenty of room for such combustion.

Contact of the particles of coal dust with other bodies results generally in the lowering of temperature to such

[1] Supplied by Duncan & Duncan.

an extent as to make combustion impossible. The result is the virtual loss of any fuel which falls down onto the lining or onto the clinker. The time of combustion is evidently increased as the size of the dust particle is increased, from which it follows that the finer the grinding, everything else being equal, the quicker and more perfect the combustion.

In the early days of the development of the process of coal burning, ignorance of the necessity of fine grinding was the cause of many failures in burning coal dust. In the cement industry special devices for regulating the supply of air for injecting the fuel are supplied, but no special controlling apparatus is supplied for the air which enters the kiln through the various openings around the hood. It would be difficult indeed to control the admission of such air. By increasing the fuel charge, it is possible to bring the air supply down to nearly theoretical, or to any relative proportion desired. I have found from tests in the cement art that best results are obtained when there is a slight deficiency rather than an excess of air. This is denoted by a short carbon monoxide flame at the base of the stack and also by analysis of the escaping gases.

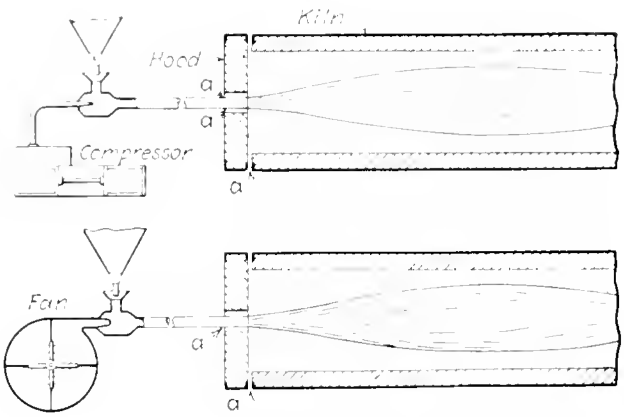


Fig. 2 Diagrams of Burner and Kiln for Powdered Fuel

Novelty of the process. Patents taken out many years ago for the burning of powdered coal under boilers and in various arts show various kinds of pulverizers and feeding devices, and also the idea of delivering powdered coal into the furnace by a jet of air or steam. Crampton suggested a pulverized coal flame for use in his type of rotary Portland cement furnace. No one, however, previous to Hurry & Seaman, seems to have comprehended the necessary underlying principle for successfully burning pulverized coal which requires the burning of the coal while in suspension and the utilization of the radiant heat of combustion without substantial impingement of the flame. The failure to recognize such requirements is, in my opinion, in a large measure responsible for the practical failure of the burning of pulverized fuel in boiler furnaces, although such furnaces, because of form and proportion, make difficult the problem of burning coal dust in suspension. In practically all of the devices which have been tried under boilers the coal dust has impigned on bridge wall or sides of the furnace or on portions of the boiler before the combustion could be completed, resulting in waste, lack of capacity, and destruction of fire-box and fire-brick linings and other portions on which the flame impinged.

FUEL

The fuel available for burning in Portland cement kilns can have a wide range of quality. The best bituminous coals are preferable, but those of quite poor quality are in successful use. I have known of the successful use of anthracite coal but it is difficult to pulverize and needs a high temperature for combustion.

The fuel used in the Eastern portions of the country is generally obtained in the bituminous mines of Pennsylvania, Maryland, Virginia or West Virginia. The coal employed in mills in the Western part of the country is frequently that most convenient to the plant and the cheapest in price on the heat unit basis.

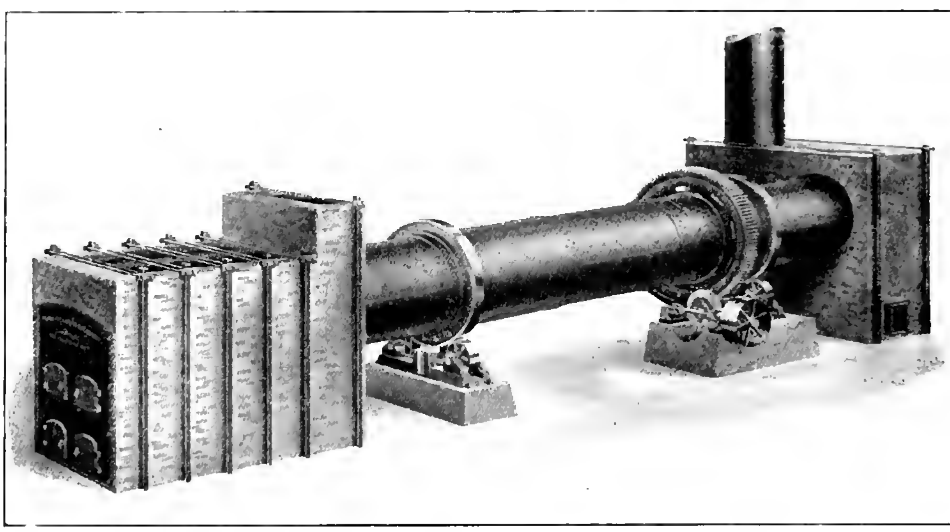


Fig. 3 General View of Rotary Dryer with Stationary Firebox

Before the coal can be ground it is necessary that it be dried so that the moisture content will be less than 1 per cent, as the water in coal seriously affects the operation of pulverizing. It also has a detrimental effect on feeding and on the capacity of the kiln. The effect of the moisture, however, depends upon the kind of coal, so that no limit can be definitely stated as essential to success in advance of a trial.

Capacity and Efficiency. The weight of pulverized coal required per barrel varies somewhat with the character of the kiln and the character of the process. In the dry process of manufacture the weight of fuel per barrel varies from about 22 to 26 per cent of the weight of cement produced, i.e., from 83 to 100 lb. of coal per bbl. In the wet process the coal varies from about 35 to 50 per cent of the finished product, i.e., from 133 to 190 lb. of coal per bbl. The theoretical amount of coal required, neglecting the heat due to the formation of silicates of lime and alumina, is probably not far from 30 lb. per bbl., provided 10,000 B.t.u. per lb. of coal is utilized. The continuous stationary kilns are reported as consuming 12 to 16 per cent of fuel or from 45 to 60 lb. per bbl. of cement.

The capacity, in barrels per 24 hours, of the modern kiln when operating on dry material with flue gases about 1000 deg. fahr., can be approximately expressed by the following formula

$$C = 0.1D^2L$$

where

C = capacity in 24 hours in bbl. of 380 lb.

D = outside diameter in ft.

L = length in ft.

The economy of the kiln has been increased by increasing its length, probably due in part to a change in the process of burning whereby the CO_2 is driven off from the material before it reaches the combustion zone in the kiln, and in part to a reduction in losses. The saving due to the use of the 150-ft. kiln in place of the 60-ft. kiln has exceeded 20 per cent in fuel and in addition has cut down the labor required in operation more than one-half. Kilns can be operated with a stack temperature less than 1000 deg. fahr. but in that event the capacity is lessened and the result is generally an increase rather than a decrease in cost.

Richard K. Meade, in his book on Portland cement, makes the following theoretical calculations as to the heat necessary per 100 lb. of raw material.

Heat required	B.t.u.	
Decomposition of 75 lb. $CaCO_3 = 75 \times 784$	= 58,800	
Decomposition of 4 lb. $MgCO_3 = 4 \times 384$	= 1,536	
		60,336
Heat supplied		
Burning of 0.3 lb. sulphur = $0.3 \times 4{,}050$	= 1,215	
Burning of 0.8 lb. carbon = $0.8 \times 14{,}540$	= 11,632	12,847
Balance to be supplied by fuel..........		47,489

About 600 lb. of raw material are needed per bbl. so that the total heat per barrel required would be 284,934 B.t.u., neglecting the effect of the silicates. The combination of the silicates and lime gives off heat. This

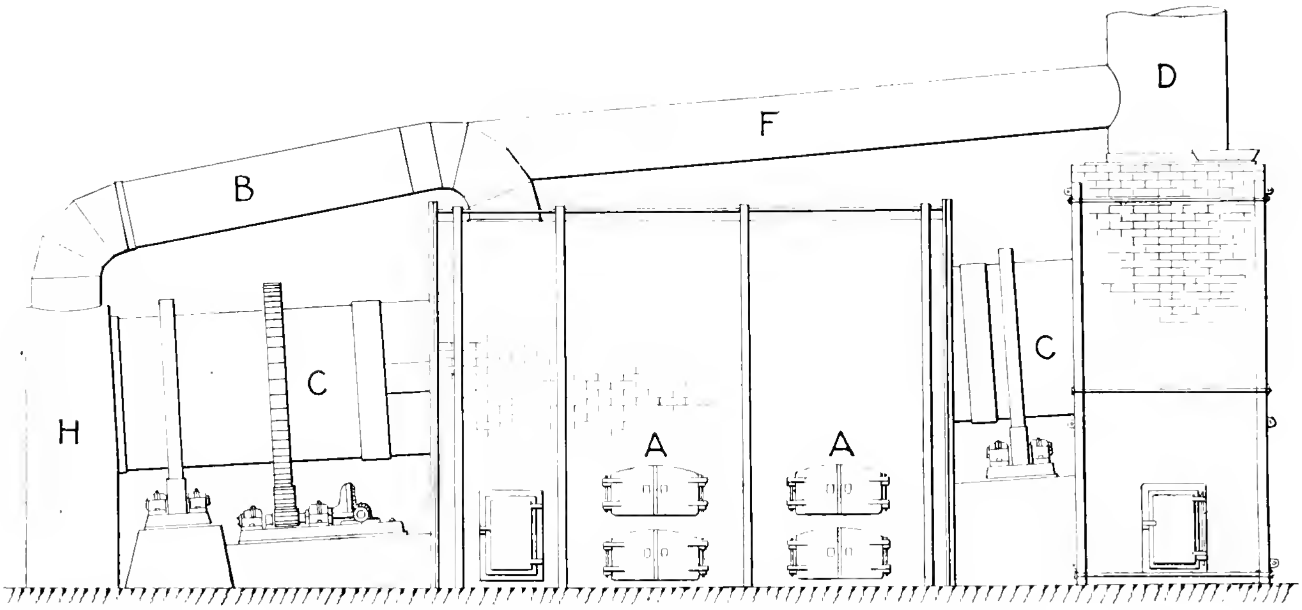


Fig. 4 Coal Dryer with Heated Gases passing through Cylinder

amount is in doubt as the exact resulting composition of the silicates is not known. A certain combination might produce 44,700 B.t.u. per 100 lb. of raw material, which is hardly possible as it would reduce the theoretical heat to be supplied to 2789 B.t.u. per 100 lb. raw material, or to 16,734 B.t.u. per bbl. of cement.

The principal cause of lack of economy in the rotary kiln appears to be due to excessive flue loss. Dr. Joseph W. Richards[1] has reported the following distribution of heat losses in a 6 x 60 kiln:

36 per cent excess air in chimney gases
36.1 per cent necessary products of combustion
10.7 per cent in hot clinker
12.8 per cent in radiation and convection

The above investigation indicates about 72 per cent flue loss of which about one-half is due to poor operation and is preventable.

In order to utilize the waste heat in the stack, I arranged in the Cayuga Lake plant to pass the discharge

[1] Engineering Record, Feb. 27, 1904.

gases of two kilns through a boiler and an economizer, the draft being maintained by a fan. I also arranged to heat the air entering the kilns by drawing it through the hot clinker discharged from the kilns. The kilns were 60 ft. in length and 7.5 ft. in diameter at the lower and 6.5 ft. at the upper end. A very complete test was made by J. W. Prince, M.E., under my general directions, of which the results are shown in Table 1.

From these data Table 2 has been computed showing the approximate distribution of heat throughout the process.

This investigation showed that about 50 per cent of the heat was discharged into the stack and of that amount about 68 per cent could be utilized in a boiler and economizer so that the ultimate flue loss was reduced to about 17 per cent of the fuel.

In the cement industry very few attempts have been made to utilize the heat of the escaping gases. So far as I know, the only successful installation of that kind is that in the plant at Kosmosdale, Kentucky. The reason why the waste heat has not been utilized to a greater extent is no doubt due to the difficulties of arranging and maintaining the waste heat boilers in good condition. I am satisfied, however, that such difficulties are not so serious as to prevent a good return on the investment. It is doubtful if the difficulties are more serious than have been overcome in the steel industry.

Since 1902 the present methods of burning Portland cement have been in successful use, and without further reference to prior methods I will give a brief description of the machines employed, without going into minute details, so that they can be made a permanent part of the records of the Society. The operations required for burning pulverized coal consist in *(a)* drying, *(b)* pulverizing, *(c)* conveying, *(d)* storage, and *(e)* feeding. All these operations are provided with special machines and will be discussed later in the paper.

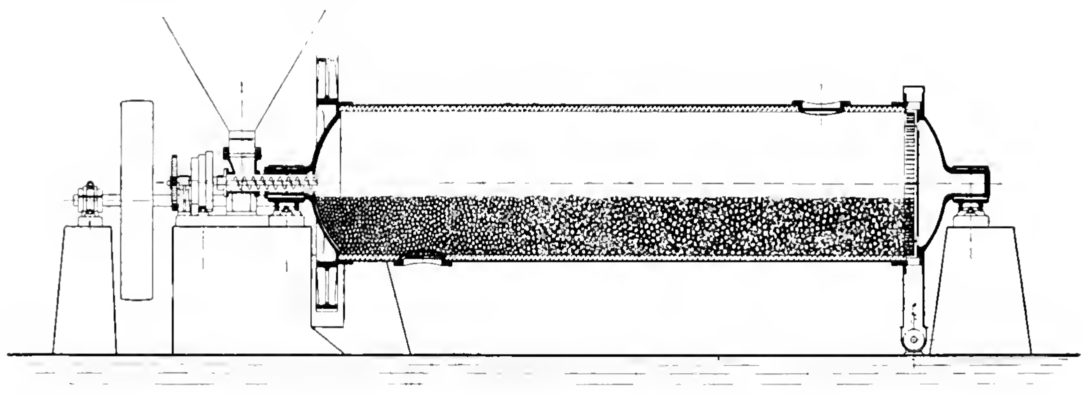


Fig. 5 Section of Tube Mill

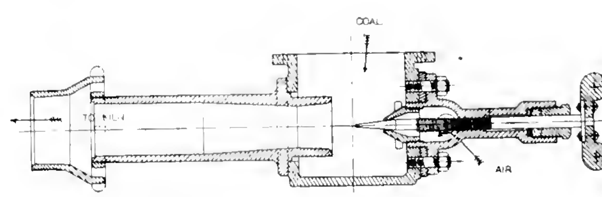


Fig. 6 Sectional View of Atlas Burner

TABLE 1 DATA TWO KILNS, EACH 7½ AND 6½ x 60

Coal consumed per hour, lb.	1888
Clinker specific heat	0.2
Clinker produced per hour (CaO = 62 per cent), lb	8018
Weight $CaCO_3$ per hour, computed, lb.	8875
Moisture in raw material, per cent	3.1
Weight CO_2 per hour from material, lb.	3660
Weight of air supplied per lb. of coal, 44 per cent excess, lb.	16.1
Total weight of air supplied per hour, lb.	32397
Weight of air supplied by coal feeders per hour, lb	5850
Total weight of gases discharged per hour, lb	37749
Heat discharged per lb. of gas, 0.23 (1800—100), B.t.u.	391
Area of outside of kiln, sq. ft	1213
Area of hood exposed, sq. ft.	76
Air entering kilns, deg. fahr.	480
Air leaving kilns, deg. fahr.	1820
Air leaving boiler, deg. fahr	660
Air leaving economizer, deg. fahr	450
Temp. of kiln by optical pyrometer, lower third, deg. fahr	2350 to 2960
Temp. of kiln by optical pyrometer, upper part, deg. fahr	2960 to 1800

DRYING

Previous to drying, the coal is crushed by passing through rolls plain or toothed, or through crushers, to

TABLE 2 APPROXIMATE DISTRIBUTION OF HEAT

	B.t.u.	Per cent
Heat entering kilns from clinker cooler	2,041,000	
Heat entering kilns from comb. of coal	26,150,000	
Heat produced from chemical reactions	632,206	
Total heat supplied	29,123,206	100
Discharged from kiln to boiler	14,859,859	51.2
Discharged with clinker (8018×2×500)	1,409,540	15.1
$CaCO_3$ decomposed (8875 lb. at 765)	6,789,375	23.3
126 lb. sulphuric anhydride liberated	238,140	0.8
252 lb. water evaporated	303,200	1.0
Radiation and unaccounted for	2,523,092	8.6
Radiation per sq. ft. of surface of kiln per hour	974	
Heat absorbed by boiler from kiln gases	8,798,328	30.5
Heat absorbed by economizer from kiln gases	1,178,998	4.0
Stack loss and boiler radiation	4,882,533	16.7

break up the large pieces. For the purpose of drying, rotary cylinders of the general character illustrated in Fig. 3, are generally employed, provided with an external furnace. The rotary cylinder of the dryer is frequently subdivided by partitions, or else provided with Z-bars, which raise the coal upward as the cylinder revolves and bring it into better contact with the heat and gases.

In some of the coal dryers, as Fig. 4, which is a dryer constructed by the Vulcan Iron Works, the discharge gases from the external furnace are arranged to pass through the dryer.

The coal to be dried is fed into the upper end of the cylinder *C*, through the hopper *K*, or other convenient means, and is discharged through the stationary hood *H*, at the lower end of the cylinder. An external furnace is located at *AA*, from which the hot gases pass to the rotating cylinder *C*, through the stationary hood *H*. There is a by-pass at *F*, by which the gases can be made to pass from the furnaces directly into the stack *D*, without having to pass through the rotating cylinder *C*.

The dried coal is usually discharged into suitable conveyors and immediately removed to bins over the pulverizing machines. This adds to the efficiency and

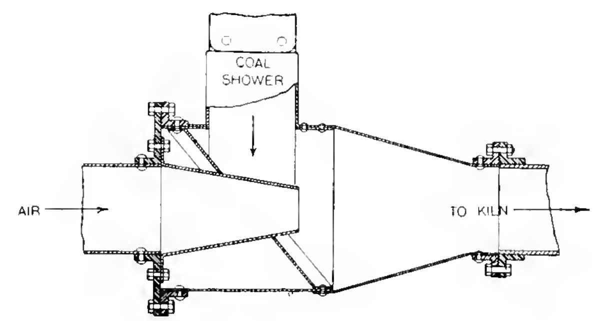


Fig. 7 Low-Pressure Burner

capacity of the dryer but also increases somewhat the danger of conflagration while in the dryer. This danger is slight; however, in practice and with good construction it is quite certain not to result in serious damage, and can always be obviated by care so that the practice is not open to serious criticism.

The coal dryer is frequently provided with a stack to remove the dust. The size of the dryer is usually selected with reference to the maximum amount of moisture to be removed. Large plants usually have from two to three dryers, of sizes varying from 4 by 40 ft. to 6 by 60 ft.

Various other types of dryers of special design and considerable merit are employed in some plants but they can hardly be considered in a paper of this general character.

The waste heat of the plant is available for use in dryers, but the amount of heat needed for the coal drying is so small as to make the installation of the waste heat equipment usually a poor investment. This statement may not apply to other dryers of the plant requiring a greater expenditure of heat.

THE PULVERIZING MACHINERY

The coal, if delivered in large lumps, is broken into small pieces by passing through plain or corrugated rolls or crushers, before entering the dryer. This machinery will not be described here as it is commonly used for such purposes in all arts.

The pulverized coal must finally have a fineness so that not less than 92 per cent will pass a sieve of 100 meshes to the lineal inch, in order to pass the usual

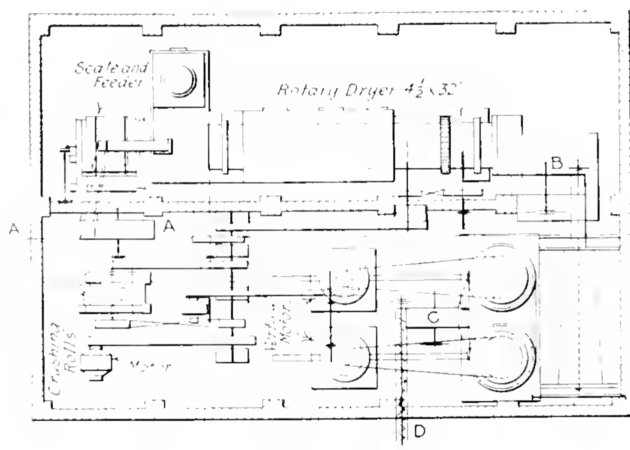


Fig. 8 40-Ft. by 60-Ft. Coal Mill, Machinery Plan

standard requirements. It is desirable to have the coal still finer. The pulverizing machinery employed is adapted to two systems of dust burning. In the first system the pulverizer is arranged so as to deliver its product directly into the kiln without intermediate storage, and has a capacity of supplying one kiln. In the second system the pulverizers have large capacity and are arranged so that the pulverized coal is stored for a short time before being fed into the kiln. The first type of pulverizer is used only to a small extent at the present time. The second type is used almost exclusively in the various cement kilns.

The Aero Pulverizer, which is of the first type, is employed in certain mills of the Universal Portland Cement Company, and consists essentially of a horizontal shaft revolving at high speed which carries beaters or revolving arms throughout a greater portion of its length and fan blades near the discharge end. When it has been sufficiently pulverized to be handled by the blast produced by the fans, it is delivered through an inlet pipe which leads directly to the kiln. The capacity is controlled by suitable dampers in the supply pipe. I am informed by the president of the Universal Portland Cement Company, Mr. Hagar, that his recently constructed mill is equipped with coal pulverizing apparatus with intermediate storage between the mill and the kiln.

The pulverizing machines mostly used in the Portland cement industry for the purpose of pulverizing coal are the Griffin mill, the tube mill and the Fuller-Lehigh mill. These are all fine grinding mills and are not adapted to receive large pieces of coal.

In the Griffin mill grinding is performed by a roll attached to the end of a vertical shaft, which is suspended by gimbal joints from a horizontal driving pulley. The grinding roll comes in contact with the interior surface of a ring of hard steel by which means the grinding is accomplished. The grinding roll, however, has a swinging gyratory motion and is not uniformly in contact against the ring. The pulverizing is therefore accomplished partly by the force of impact and partly by a rubbing motion.

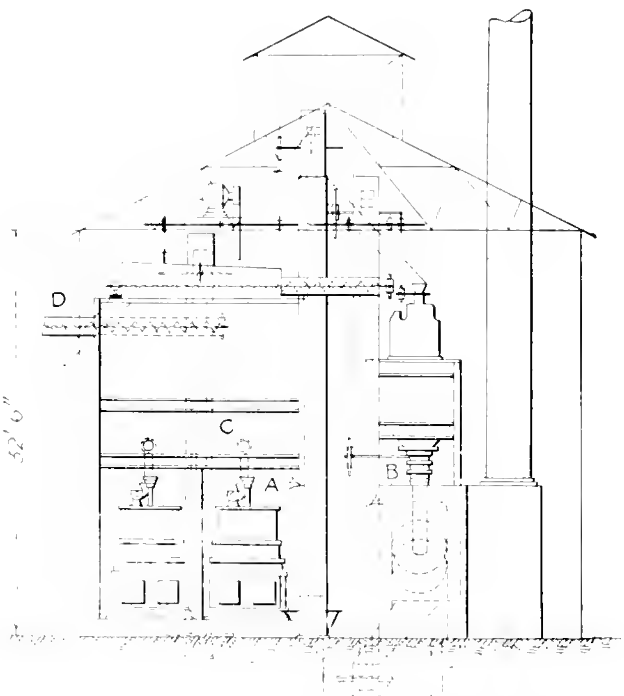


Fig. 9 40-Ft. by 60-Ft. Coal Mill, Dryer and Mill Elevation

The bottom of the grinding roll carries projections which continually throw the coarse particles to be ground from the bottom of the mill up against the internal surface of the ring, where it is pulverized. The ground material is then thrown upward and outward by fan blades attached to the shaft which supports the grinding roll, causing the material to impinge against a screen which allows the fine particles to pass through, but preventing the escape of the coarser particles.

The Griffin mill is a very effective grinding machine and is economical in the use of power. It is objectionable principally because of the dust which it produces. It has a capacity of pulverizing to a fineness of over 90 per cent through a sieve with 100 meshes to the lineal inch, as follows, for the two sizes of mill which have been made:

30-in. mill, 2 tons per hour	35 h.p
40-in. mill, 4 tons per hour.	65 h.p.

The 30-in. Griffin mill is in extensive use but is no longer manufactured.

The tube mill is extensively used for grinding coal, also for grinding rock and finished material in cement mills, and is constructed by several manufacturers. It consists essentially of a large cylinder mounted on hollow trunnions at the ends, a section of which is shown in Fig. 4. The cylinders vary in diameter from 4 to 6 ft. and have a length varying from 22 to 30 ft. The material to be pulverized is fed through a hollow trunnion at one end and is discharged at the opposite end. The cylinder is filled about 40 per cent full with hard silicious pebbles usually somewhat elliptical in form and having diameters not greatly different from 2 in. The mill is lined with some tough materials which can be readily replaced, such as silica blocks or plates of steel.

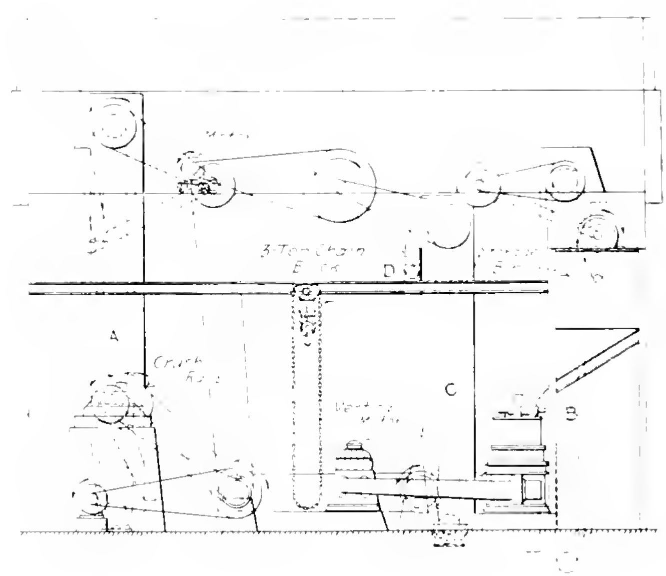


Fig. 10 40-Ft. by 60-Ft. Coal Mill, Elevation showing Fuller Mills

The rotation of the cylinder lifts the load of pebbles and material being pulverized and causes the pebbles to roll and slide over the material to be ground as it passes through the mill. The result is an extremely fine product. The 50-in. tube mill 22 ft. in length has a capacity of about 4 tons of coal per hour and requires about 75 h.p. The tube mill is practically dustless and is noiseless. But it requires very dry coal to be successful.

The Fuller mill is probably the most extensively used of any grinding mill for coal in the Portland cement industry in this country. This mill is a comparatively new one and is manufactured by the Lehigh Car Wheel & Axle Works, at Fullerton, Pa. In this mill the pulverizing element consists of four steel balls which roll in a stationary horizontal concave-shaped grinding ring. The four balls are propelled around the inside

of the grinding ring by means of four pushers. Directly above the pulverizing zone is a separating chamber which is completely encircled by a screen of woven wire cloth. The material is thrown against the screen by a fan keyed direct to the main shaft and revolving with it. Outside of the screen and separated from it by several inches of space is an outside casing through which all the finished material passes. There is also an exhaust fan beneath the pulverizing zone which induces a discharge through the screen and also tends to facilitate the discharge of the ground material. The material to be pulverized is fed from a hopper at the top of the mill by special feeding mechanism to the pulverizing zone. The mill is driven by means of a pulley or gears attached to the main shaft below the pulverizing zone.

The Fuller mill is constructed in two sizes, 33 in. and 42 in. The capacity of the 33-in. mill is given as 2 to 2.5 tons per hour for an expenditure of from 30 to 35 h.p., and of the 42-in. mill as 4 to 6 tons per hour with an expenditure of 45 to 50 h.p.

In addition to the pulverizing mill described in this paper, other mills are employed to a limited extent. The Atlas Portland Cement Company employ Huntington mills for coal grinding which they manufacture in their own shops. The Huntington mill is in structure much like the Griffin mill but it is provided with three pulverizing rolls instead of one.

CONVEYING MACHINERY

I shall make no attempt to describe the conveying machinery employed in modern cement mills for conveying the coal to the various parts of the mill. This machinery differs greatly in the different mills. In the great majority of mills screw conveyors are employed for moving the coal horizontally and bucket and chain elevators encased in dust-proof housings of steel for moving it vertically. In other mills belt conveyors and pan conveyors are used.

The requisite for safe conveying is the prevention of an explosive mixture of pulverized coal and air. Neglect of this precaution has caused the loss of many lives and the destruction of a great deal of property in the Portland cement industry. The present practice endeavors to keep the pulverized coal from mixing with air so that if it should happen to catch fire it would burn slowly without producing disastrous explosions.

STORAGE OF PULVERIZED COAL

Storage capacity for pulverized coal, because of the element of danger, should be as small as possible consistent with the continuous operation of the mill. It is customary to provide for each kiln a storage bin with a capacity of from 6 to 10 hours of operation. Such bins are usually located 15 to 20 ft. from the lower end of the kilns where they do not interfere with the operation. Each bin is supplied by a conveyor leading from the pulverizing machine. The ordinary location with reference to the kiln is illustrated in Fig. 1. In this drawing the coal bin, shown at K, is of a cylindrical form with a cone-shaped bottom. The pulverized coal is supplied to the bin through a screw conveyor at the top of the bin, shown at L. It is discharged from the bottom of the bin by means of a screw. Coal storage bins of rectangular cross section are equally serviceable.

FEEDING THE COAL

Powdered coal is fed from the bottom of the bin by adjustable feeding arrangements generally consisting of a double-threaded screw conveyor having a variable feed, one type of which is illustrated in Fig. 1. The coal dust is blown into the kiln by a jet of air with some type of injector. In some of the plants com-

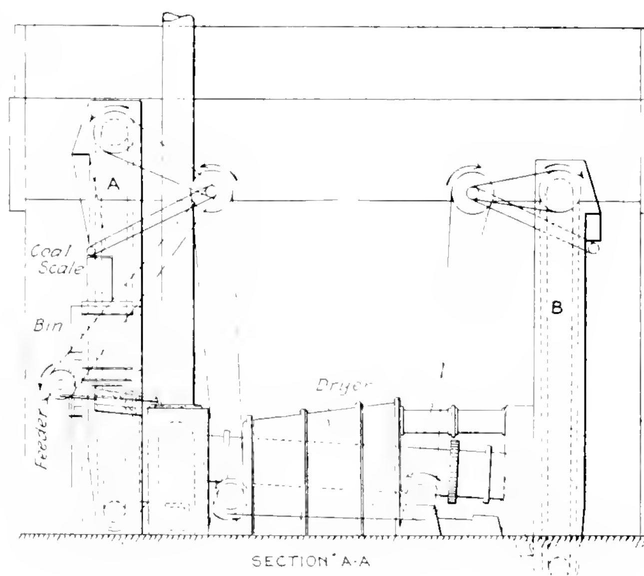


FIG. 11 40-FT. BY 60-FT. COAL MILL, ELEVATION SHOWING DRYER

pressed air of from 30 to 40-lb. pressure is employed for delivering the pulverized coal; in other plants air is obtained from a rotary fan at about 2 ounces pressure. Fig. 6 illustrates a type of high pressure burner extensively employed by the Atlas Company. The drawing clearly shows the construction and mode of operation. Fig. 7 shows a common type of low pressure injector. The drawing shows the construction of the injector, from which the mode of operation will be readily understood.

The coal feeding injectors are located in front of the stationary hood and arranged to deliver the jet of coal dust axially to the kiln. Practice has proved that it is unnecessary to use more than one jet to a kiln, although in some of the constructions two jets are used. The detailed construction of injectors for feeding the pulverized fuel differ in the various plants, but all embody the features illustrated in Figs. 6 and 7.

COMPLETE INSTALLATION OF PULVERIZING MACHINERY

I present a set of drawings which show a complete installation of coal pulverizing machinery having a capacity of about 8 tons per hour. These drawings I have selected as illustrating simply and completely the machinery needed for a coal pulverizing equipment. They were prepared by the Lehigh Car Wheel & Axle Works and are submitted by permission. They appear as Figs. 8 to 11 in connection with this article. Fig. 8 is a plan view showing the arrangement of the machinery. Figs. 9, 10 and 11 are vertical sections which show the locations in a vertical plane of various machines. By reference to these drawings it will be noted that machinery is provided for crushing the coal in crushing rolls, elevating the crushed coal in a dust-proof elevator *A*, to the top of the mill where it discharges by gravity through a coal scale and then into the upper end of a rotary dryer. The coal passes through the dryer which removes the moisture, then it is discharged into a dust-proof elevator *B*, and raised to a height sufficient to fall by gravity into the storage bin for dried coal located at a higher level than the pulverizing mills. From these storage bins the coal is drawn by gravity into the pulverizing mills. The pulverized coal is then raised by a dust-proof elevator *C*, to a point where it is discharged into a screw conveyor *D*, leading to the storage bins near the kilns. The drawings show the various machines as driven by electric motors, which is customary in the art. The rotary dryer is of the general type of one already described in this article and has a rotary cylinder 4 ft. 6 in. in diameter by 32 ft. in length.

The paper is intended to give an idea of the difficulties overcome and the results attained in the burning of pulverized coal in the cement industry without referring to many details of construction. The process of burning in the cement kiln is described quite at length in order that the reader may understand the peculiar character of the problem involved in the cement industry and the differences of the combustion processes in that art and in the steam boiler furnace. It is hoped that a full discussion will give additional information on this subject which will tend to improve the efficiency of combustion in all arts.

In the preparation of this article information has been supplied by the Atlas Portland Cement Company, H. J. Seaman, general superintendent, A. G. Croll, assistant superintendent; the Universal Portland Cement Company, Edward M. Hagar, president; the Helderberg Portland Cement Company, F. W. Kelley, general manager; the Cayuga Lake Portland Cement Company, M. E. Calkins, president; the Allentown Portland Cement Company, J. W. Fuller, president. Valuable information and drawings have also been received from the following manufacturers of cement machinery: Allis-Chalmers Company, Milwaukee; Bradley Pulverizer Company, Boston; Lehigh Car Wheel & Axle Works, Catasauqua, Pa.; Power & Mining Machinery Company, Milwaukee; Thomas Prosser & Son, New York; F. L. Schmidt & Company, New York; Vulcan Iron Works, Wilkes-Barre.

PULVERIZED COAL FOR STEAM MAKING

BY F. R. LOW, NEW YORK CITY

Member of the Society

Numerous attempts have been made in the past quarter century to use pulverized coal as a boiler fuel. The published accounts of the various trials are full of promise and apparent accomplishment, but few of the processes have persisted, and only a small proportion of the coal used in steam making is fired in this way.

There have been three broad types of apparatus produced: that of which the Pinther (Fig. 1) is typical, where the prepared coal is emptied into a hopper above a feed-controlling mechanism and carried into the furnace by the natural draft; that having a mechanical feed, as the revolving brush of the Schwartzkopff apparatus (Fig. 2); and that in which the coal is blown into the furnace, as in the Day or Ideal apparatus (Fig. 3).

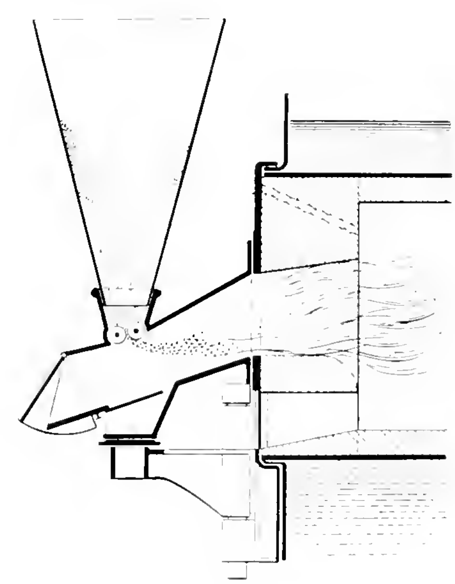


FIG. 1 PINTHER TYPE OF APPARATUS

With the first type efficiencies of from 75 to 80 per cent were obtained, but the capacity was limited. When sufficient draft was applied to introduce a considerable amount of fuel, the velocity was such as to carry unconsumed particles of coal into the back connection and tubes. When fuel is introduced into a powdered fuel furnace at a rate which will give the full rated capacity of the boiler, a particle will remain in the combustion zone of an ordinary furnace less than half a second.

The first installation that I ever saw for burning pulverized coal under a boiler was of the rotary brush type. It was promoted by Mr. Bradley, an extensive fertilizer manufacturer, I should say in the late nine-

Presented at the Spring Meeting, at St. Paul-Minneapolis, 1914, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

ties. It was but a step from pulverizing fertilizer to pulverizing coal. The apparatus was applied to a horizontal-return tubular boiler at Quincy, Mass., set in the usual way. The brush injector was placed at the furnace door and upon the grate was a thin fire composed of coal of about the size of hickory nuts. There was no way of feeding coal to this fire and none was necessary. Enough of the coal failed to be consumed in suspension, and fell and agglomerated itself upon the fuel bed to keep it supplied. The powdered coal

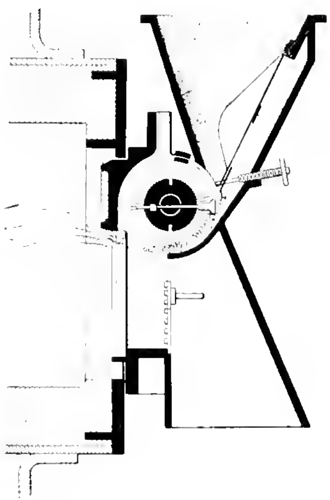


Fig. 2 Schwartzkopff Apparatus

was brought in bags and dumped into the hopper above the brush. The chimney was smokeless, the fire box cloudy, but the combustion chamber full of clean white flame. It looked very promising, but never reached the publication stage.

When it is suggested that an air blast be used to introduce the fuel, the apprehension of an excess of air is natural. The relative volumes of equal weights of coal and air are about 1:990. It would hardly be expected to use less than 15 lb. of air per pound of coal, so that the relative volumes of coal and air introduced would be

$$1:(990 \times 15) = 1:14{,}850.$$

The diameter of the globe of air which would accompany each tiny particle of fuel into the furnace would be $14{,}850 \sqrt[3]{14{,}850}$, or over 24 times the diameter of the particle of coal, so it will be seen that plenty of air may be used for fuel injection purposes without exceeding the supply required for complete combustion. In all of the systems at present in use, the fuel is introduced in this way, the blower usually being so combined with the pulverizer that the pulverized coal is blown into the furnace as fast as it reaches the necessary degree of fineness.

That the subject has not been neglected by inventors is evidenced by the fact that during the past 20 years there have been 23 United States patents issued for pulverized coal apparatus.

The earlier attempts to utilize pulverized coal were in connection with metallurgical processes. J. S. Dawes used it in England, in 1831, in blast furnaces, injecting it with the air through the tuyeres. It was proposed or tried in iron works by Desboissierres, in 1846, by Mouchel, in 1854, and by Mushet, in 1856. Somewhat later, Crampton tried it in locomotive and other boilers.

In the Engineering and Mining Journal of 1876, Chief Engineer B. F. Isherwood, U.S.N., described a test made by naval engineers under his direction in

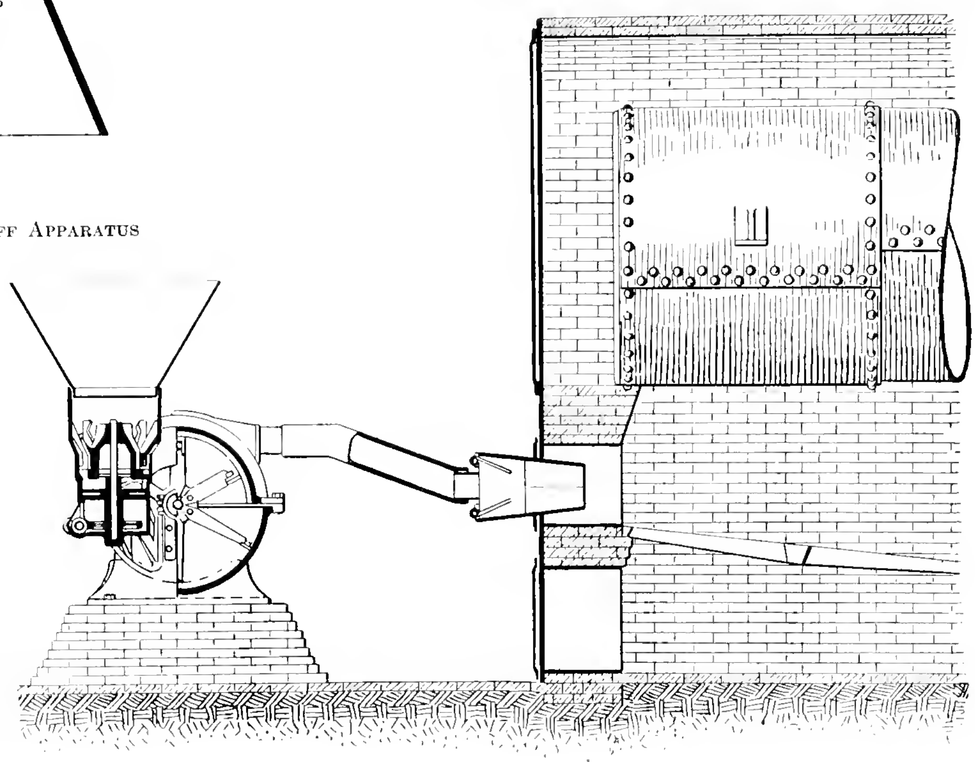


Fig. 3 Day or Ideal Apparatus

1867 and 1868 at South Boston, upon an apparatus devised by James D. Whelpley and his partner, Storer, for firing a boiler in part with pulverized fuel. The boiler was of the horizontal two-flue type having only 299 sq. ft. of heating surface and $13\frac{1}{2}$ sq. ft. of grate. A coal fire was maintained upon the grate and the pulverized fuel fed in above it, a fire arch being used to maintain the furnace temperature when the powdered fuel was used, but not with the grate alone.

Tests were made both with anthracite and semi-bituminous coal. The highest rates of combustion at-

tained were 15.8 lb. per sq. ft. of grate per hour for the anthracite, and 11.9 for the bituminous, referring all the coal burned, pulverized as well as solid, to the grate area. Mr. Isherwood's conclusions were that, including the cost of pulverizing, the anthracite did a good deal better and the semi-bituminous a little better, when burned upon the grate in the ordinary way than when burned in part in the pulverized condition.

In the late nineties, D. Wegener brought out in Europe and tried in this country a natural draft system. Tests showed boiler efficiencies of from 75 to 80 per cent.

In 1910, J. E. Blake, of the Blake Pulverizer Company, installed, under a 300-h.p. water-tube boiler, at the Henry Phipps power plant in Pittsburgh, the arrangement shown in Fig. 4. The pulverizer served as its own blower, sending the pulverized fuel mixed with air to the furnace, where, in this installation, it was introduced by a series of nozzles extending across the width of the furnace. A little less than the rated horsepower of the boiler was obtained with an efficiency of about 79 per cent.

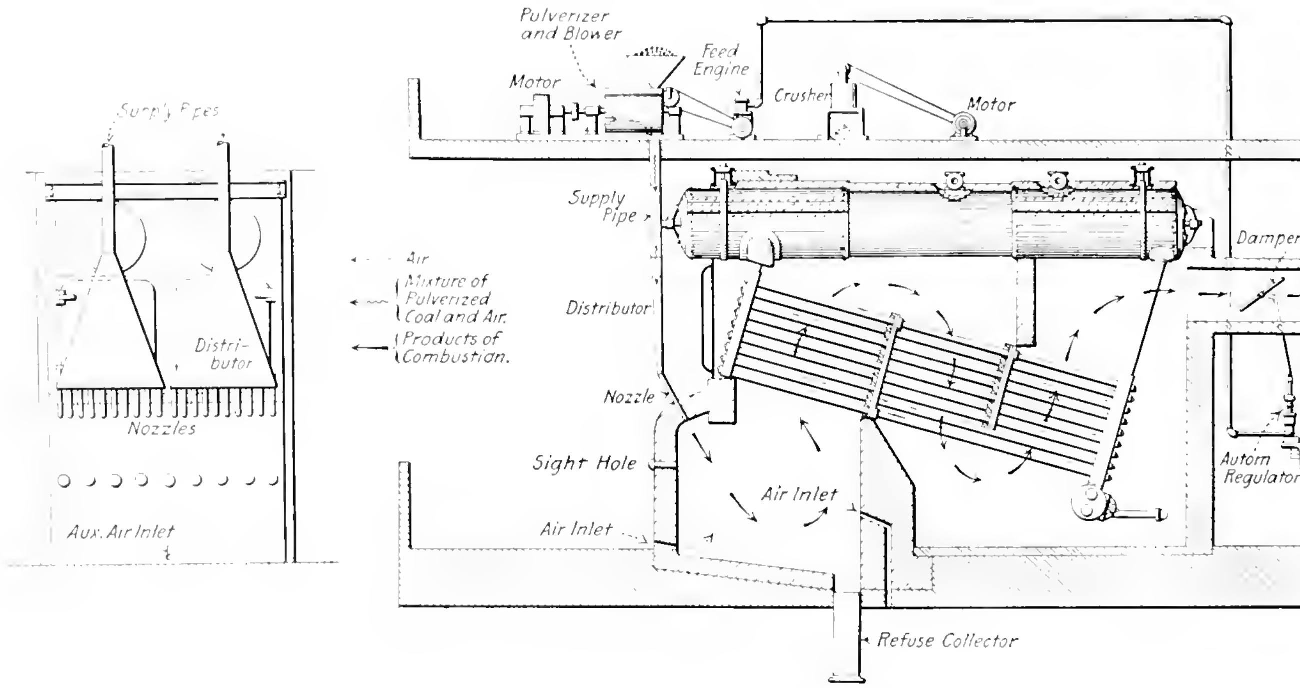


FIG. 4 BLAKE AND PHIPPS INSTALLATION

A later form of the Blake apparatus was installed last winter at the Peter Doelger Brewery in New York City. The powdered coal was delivered into the top of an extension furnace or Dutch oven, as shown in Fig. 5. Smokeless combustion and high efficiency were obtained, the principal trouble being from slag, which accumulated on the roof and sides of the furnace, and piled up in such masses upon the floor that frequent shutdowns were required for its removal. They evaporated as much water with 1000 lb. of the pulverized as with 1400 lb. of the natural coal, but the cost of furnace maintenance, the frequent laying off of the boiler for the removal of slag and the cost of pulverizing counteracted in the opinion of the operators these advantages and the system was abandoned after a trial of about eight weeks.

In 1905, John B. Culliney, Superintendent of the American Steel & Iron Company, patented the controlling device shown in Fig. 6. The powdered fuel is deposited in the hopper *A*, filling the chamber *B* directly beneath it, whence it is carried forward by the horizontal screw conveyor and dropped in a continuous stream through the chamber *C*. Radial rods upon the conveyor shaft agitate the mass, and push any foreign or uncomminuted material which may have been introduced with the fuel out to the sides, where swinging cover plates *DD* are provided for its removal. Connected to each side of the chamber *C* is a blast pipe *E*, the opening for which is shown in the longitudinal section at *F*. A current of air flowing through the pipe and across the falling stream of pulverized coal picks up a portion of it and carries it to the larger pipe *G*, where it is taken up by another air current and carried into the furnace. About one-seventh of the total air is supplied at the smaller pipe under a pressure of about 6 oz., the remainder of that necessary to complete combustion being supplied by the larger pipe under a pressure of $1\frac{1}{2}$ oz. or less. The part of the coal which is not taken up by the blast is returned to the upper chamber by the inclined screw of coarser pitch, and carried forward again through the same process. Regulation of the speed of the conveying screws, and of both air supplies, gives the operator complete control of the rate of feeding and character

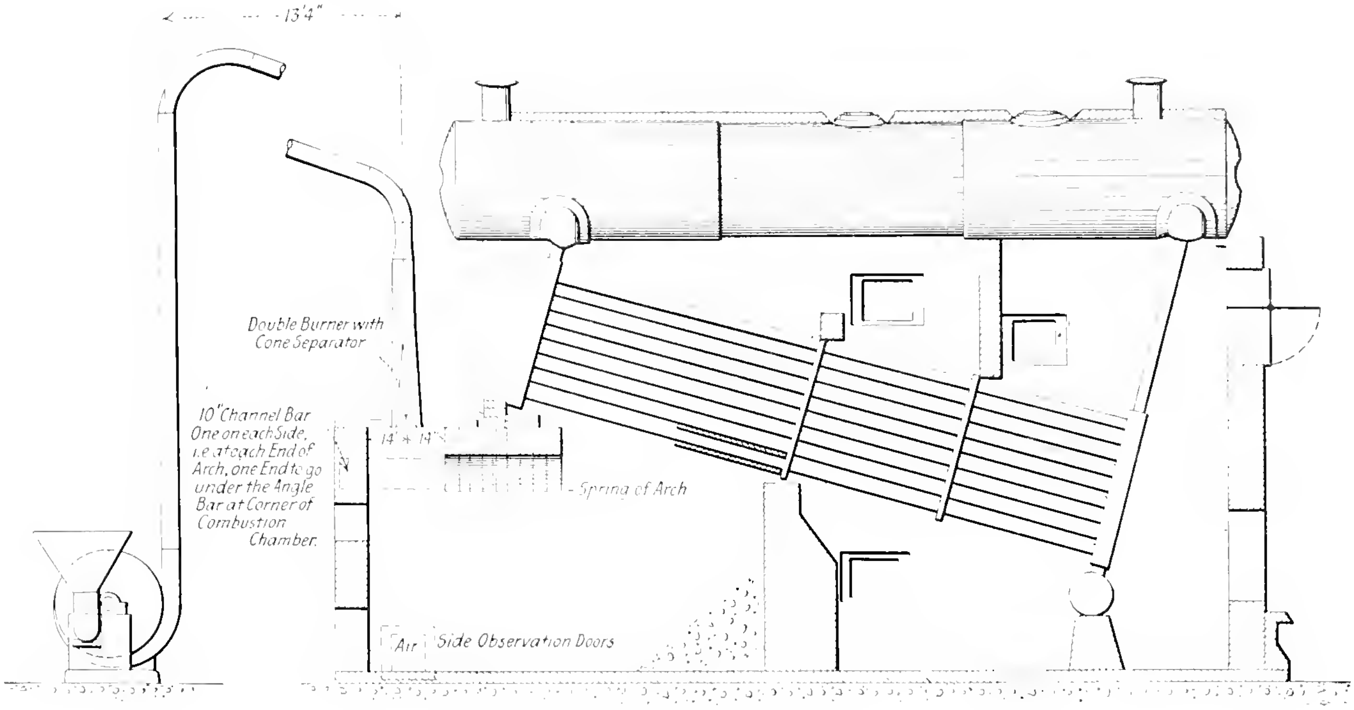
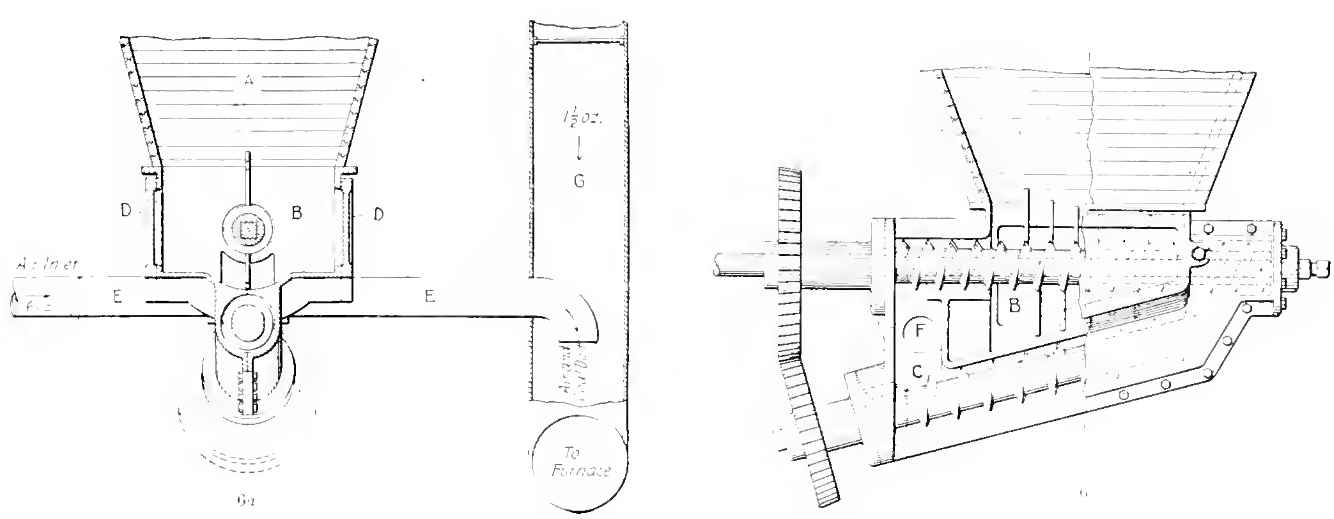


FIG. 5 DOELGER INSTALLATION

of the flame. This system has found a wide application, not only for large metallurgical work, but for many furnaces where oil and producer gas were formerly used, and was used for a number of years under boilers at the works of the Erie Malleable Iron Company until the purchase of current from the electric company made the operation of the boilers no longer necessary.

This system has been for some time in successful use for shop processes at the Schenectady works of the American Locomotive Company, and has recently been installed for steam making purposes under a 300-h.p. Franklin boiler. The arrangement is shown in Fig. 7. The results, up to this writing, have been complete smokeless combustion, no slag, several furnace linings melted down, but inability to get full boiler capacity. This is laid to limited controller capacity, and larger controllers are being installed. It is hoped that further information will be available before the date of the meeting.

Claude Bettington of Johannesburg, South Africa, where the price of coal is high, attacked the problem by designing a boiler especially for use with pulverized fuel. He took out his first patent in the United States, but his boiler was first commercially exploited in England. He met his death in an aeroplane accident some two years ago. In his boiler the feed is upward, as shown in Fig. 8, through a water-jacketed nozzle in the center of a vertical furnace. The pulverizer acts as a blower, and the air supply is preheated. From the



FIGS. 6a AND 6b CULLINEY FEEDING

pulverizer the coal passes to a separator, where the larger particles settle out and return to be again treated, the finer passing on to the burner. The blast, about 2 in., opposing gravity, tends to keep the coal in suspension, and as a particle would have to pass twice the length of the furnace (upward and downward) to escape, there is no difficulty in obtaining complete combustion.

The flame does not lift more than 10 per cent under the highest rate of feed which it is practicable to employ, the temperature of the furnace and of the enveloping gases being increased enough to offset the greater velocity of ingress. The tubes of the inner row of the circular furnace are covered with a special refractory covering to within a short distance of the bottom header, making a brick-lined combustion chamber. The special bricks are placed loosely around the tubes, but soon become coated with molten ash and slag, which welds them into a solid wall, and closes the crevices between the lining and the top header. The ash which is not so slagged to the furnace surfaces, or carried out by the draft, drips into the ashpit below the lower header. The destructive effect of the impinging flame upon the brickwork is avoided by taking it upon the lower head of the central drum, or upon the accumulation of gas in the upper end of the chamber, the region of greatest heat intensity being in the core, while the tubes and shell are subjected to the lesser temperature of the somewhat cooled gases, which have not yet got away. The radiant heat is, however, effective upon them and the metal surfaces must be kept perfectly clean, and particular care taken as to the water level. One of these boilers having 2606 sq. ft. of heating surface has been running for over four years at the works of the builders. It evaporates regularly 14,000, and has been worked up to 22,000 lb. of water per hour. These rates, however, (5.4 and 8.4 lb. per sq. ft. of heating surface) are attained with stoker fired boilers.

A contributor to Power who has had two of these boilers in charge says that the steel head of the upper drum burned through at one time, probably due to dirt collecting upon it; that in spite of the cooling effect of the tubes the special bricks forming the furnace quickly burn away, and frequent renewals are necessary. Care must be taken lest the lining burn through and the gas be short-circuited. Although this boiler will burn low-grade fuel successfully, and while under steam is easily managed, one fireman being able to look after several boilers, these advantages are largely offset in his opinion by high cleaning and maintenance charges.

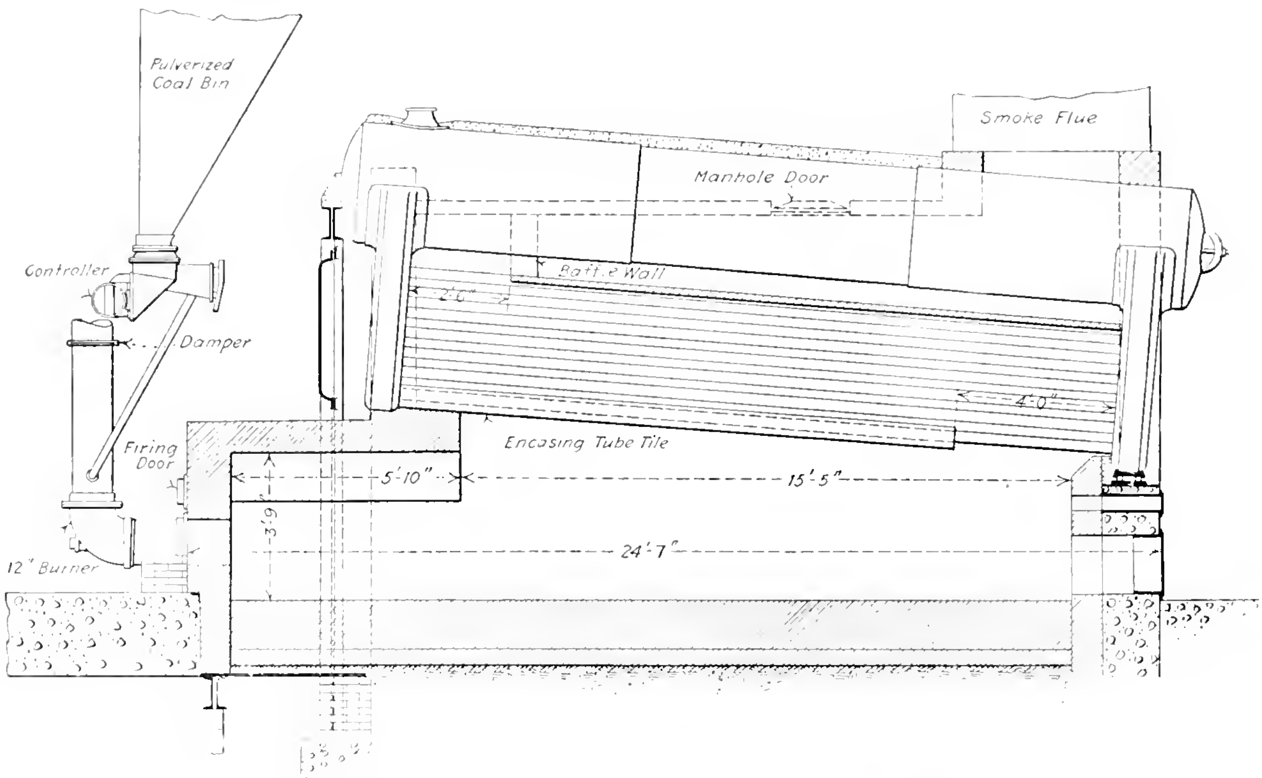


Fig. 7 300-H.P. Franklin Boiler, American Locomotive Company

The makers say their experience has been that a lining will last about two years, and that even large holes will automatically seal up. The parts which require most frequent renewal are the beaters and liners of the pulverizer. These are of manganese steel, and can be replaced in about two hours. The makers claim an approximate life for the beaters of 1500, and for the liners of 2000 tons of coal handled. A user, after 10 months' experience, says that the blades run from 1000 to 1200 hours per set, and that the second set of liners

was still in use. The use of heated air in the pulverizer allows coal having 15 per cent or more of moisture to be handled successfully; a separate heater is recommended for large boilers. They allow 2 to 3 per cent of the boiler capacity for pulverizing. There was some trouble from leaky water jackets putting the flame out, but this has been overcome by the use of welded jackets.

A number of these boilers are in use in South Africa, in Great Britain and Canada. Tests of one of the Rand boilers show an efficiency of 82.6 per cent, the coal having 2.15 moisture, 22.8 volatile, 57.55 fixed carbon, 17.5 ash. The CO_2 is carried at 15 per cent in regular practice.

With the ordinary method of burning coal, the grate with its bed of solid incandescent fuel more or less encumbered with ash and clinker, offers a considerable, a varying, and an uneven resistance to the passage of air, rejects the incombustible residuum with some difficulty and allows some of the unburned fuel to sift to the ashpit or to be fused in with the clinker. If the fuel can be burned in suspension, many of these difficulties disappear and the draft-producing apparatus is reduced to that which will remove the products of combustion and allow enough air to enter to burn the required amount of fuel. There still remains, however, the difficulty of getting rid of the incombustible. With 10 per cent ash there will be 200 lb. of refuse to be got rid of with each ton of coal burned. If this is kept in a pulverized form it is carried into the back connection, the tubes and stack, and scattered about the neighborhood. If it is fused it attaches itself to the surfaces of the furnace and welds itself into masses, occasioning damage to the brickwork in its removal and comparatively frequent layoffs for cleaning. In one instance the molten slag formed in sheets and ridges upon the sides and in stalactites upon the roof of the furnace, while the floor was covered with a plastic mass, which cooled when the door was opened for its removal, and could hardly be got out without material damage to the furnace.

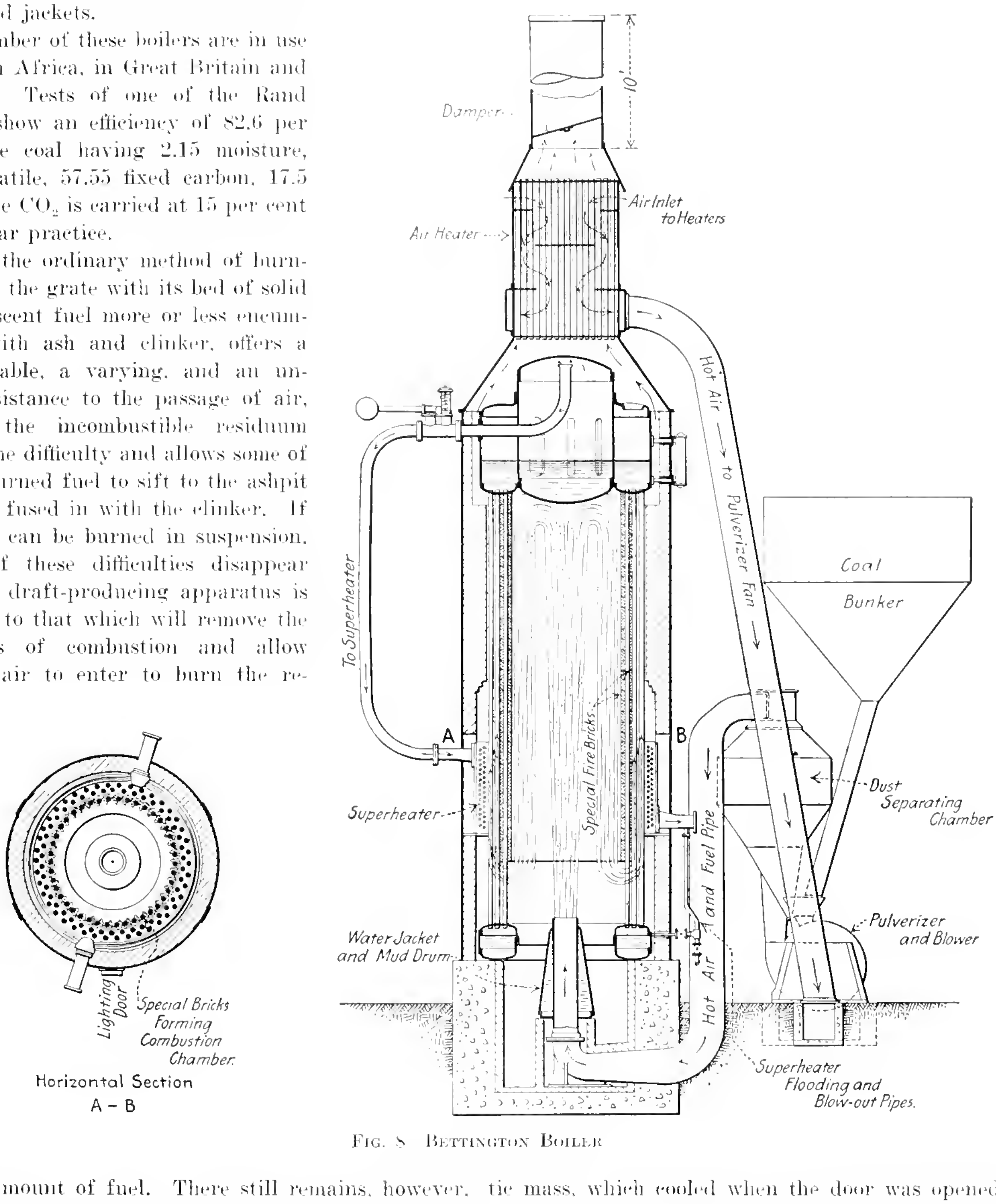


Fig. 8 Bettington Boiler

The possibility of getting an adequate supply of oxygen to the finely comminuted carbon allows perfect and smokeless combustion with a minimum air supply, but with the rates of combustion demanded in present prac-

tice, the result is a high temperature with erosive and reducing characteristics which, however good they may be for metallurgical processes, are not favorable to the longevity of a boiler furnace. If this temperature is kept down by feeding less fuel, the capacity is limited, while if it is kept down by using an excess of air the economic advantage just cited is sacrificed.

There have been several disastrous explosions of the prepared fuel outside of the furnace; but these can be easily guarded against. Coal, however finely comminuted, does not contain the elements necessary for its own combustion, and if ignited will burn only slowly if kept in a compact mass. It is only when it is diffused in a cloud that the oxygen of the atmosphere can get to it quickly enough to make the rate of combustion dangerous. The pulverized fuel can be safely conveyed en masse in suitable holders, in screw conveyors, or even in cars and barrows if care is taken that it shall not be blown or sifted about in a finely disseminated state. In those systems where the pipe back of the blower is filled with an explosive mixture of coal and air, the rate of flow must exceed that of the propagation of flame in such a mixture, and in shutting down the coal supply should be shut off first. The pulverized mass will run like water, so that the pitch of chutes, conveyors, etc., must be so set as to provide against the flowing of their contents.

While anthracite dust can be used it burns more slowly than coal having a higher percentage of volatiles, and must be very finely pulverized. For most systems practically all of the coal should go through a screen having 100 meshes to the inch, and for coals having a small percentage of volatile or where very rapid combustion is imperative the coal is ground to a fineness which will permit the greater part of it to pass through a 200-to-the-inch sieve. Low-grade coals and coals having a large percentage of ash can be burned in this way, but there is a limit to the proportion of slate and bone that one can afford to grind, and an increasing proportion of ash means increased trouble from dust and slag. The earlier practice of taking up the impingement of the flame on a checkerwork or a heap of brickbats is out of favor. It simplifies the process of keeping the burner lighted, but burns up too much firebrick and makes a locus for the building of a slag heap. With an ordinary firebrick furnace well heated up there is no trouble in maintaining the flame steady, and it will re-ignite after having been turned out for several minutes.

The cost of pulverizing and the large initial cost of the drying, pulverizing, conveying and feeding apparatus, together with the fact that coal of practically all grades can be burned with a tolerable degree of smokelessness in the cheaper apparatus in common use with a degree of efficiency which leaves little margin to cover the increased expenditure, have combined to restrict the use of pulverized coal for boiler purposes to special instances.

AN INSTALLATION FOR POWDERED COAL FUEL IN INDUSTRIAL FURNACES

BY WILLIAM DALTON, SCHENECTADY, N. Y.

AND

W. S. QUIGLEY, NEW YORK

Members of the Society

At the works of the American Locomotive Company, Schenectady, N. Y., there have been in use oil furnaces for heating the blanks for drop forgings and general small forge work, and hand-fired coal furnaces for the heavier work in the hammer shop. The equipment is now being changed to burn powdered coal fuel and a milling building has been erected to contain the coal drying and pulverizing apparatus.

The advance in the price of fuel oil in 1912 and the refusal of the oil companies to guarantee deliveries or to renew contracts for any considerable length of time led to an investigation in order to determine what fuel would be a satisfactory substitute for oil.

The apparatus installed was that developed by the American Iron and Steel Manufacturing Company at their Lebanon and Reading works and now handled by the Quigley Furnace and Foundry Company, New York. The plant was built and started in May, 1913, and while there has been the usual amount of trouble in getting a new fuel system to run smoothly, the results have been satisfactory.

The coal milling and distributing plant is motor-driven and centrally located in a building of non-combustible construction. At present it has a capacity of 5 tons an hour, and is so arranged that by duplicating the dryer and pulverizer its capacity can be doubled. This plant has a concrete hopper placed under an elevated track where it can be served either by discharging directly into it from the car or from the stock pile by means of a traveling crane and grab bucket. The concrete car hopper discharges into a rotary crusher capable of reducing 20 tons per hour of run-of-mine coal to 3/4-in. cubes, from which it is carried by means of a bucket elevator to a storage bin which discharges by means of chutes and reciprocating feeder into an indirect-heat type dryer of 6-tons per hour capacity. From here it is elevated to a dried coal storage bin arranged to feed by chutes directly into the pulverizer, then elevated to a pulverized coal storage bin, from which it is distributed by screw conveyors to the drop forge and hammer shops. The plans permit of further extension to the blacksmith shop, power plant and other departments later (Figs. 1, 2 and 3).

The milling building is detached, well ventilated, and built in conformity with the underwriters' requirements and accepted by them on a par with buildings

Presented at the Spring Meeting, at St. Paul-Minneapolis, 1914, of The American Society of Mechanical Engineers.

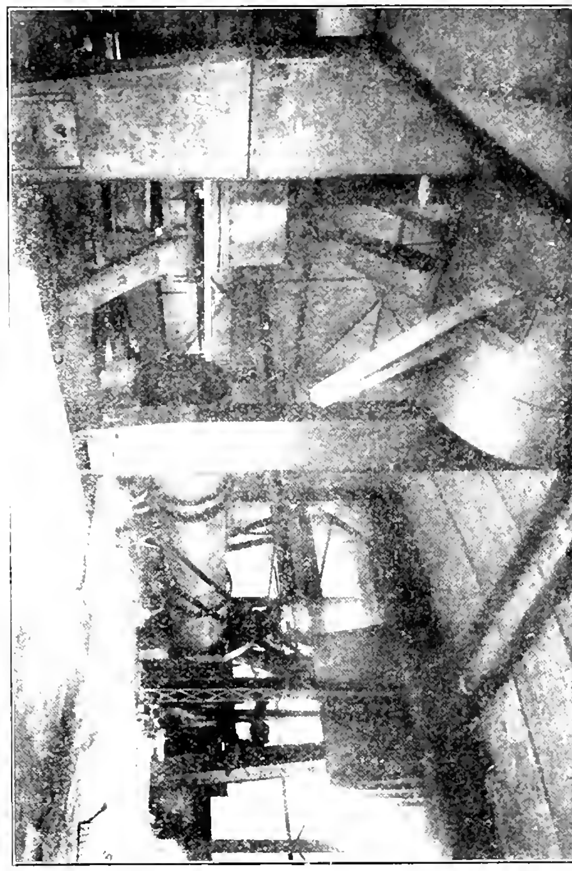


Fig. 1 — Milling Building, showing Bins, Drier, Pulverizer, etc.

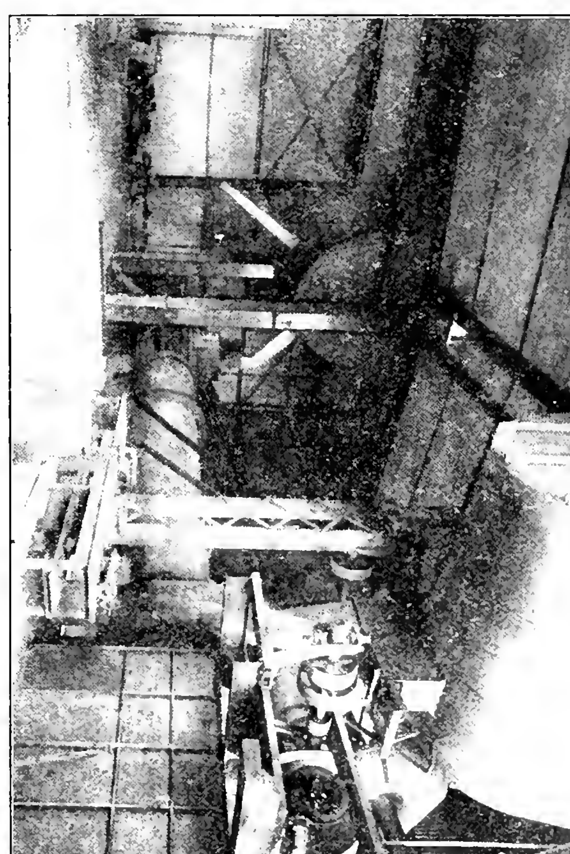


Fig. 2 — View from Opposite Side of Milling Building.

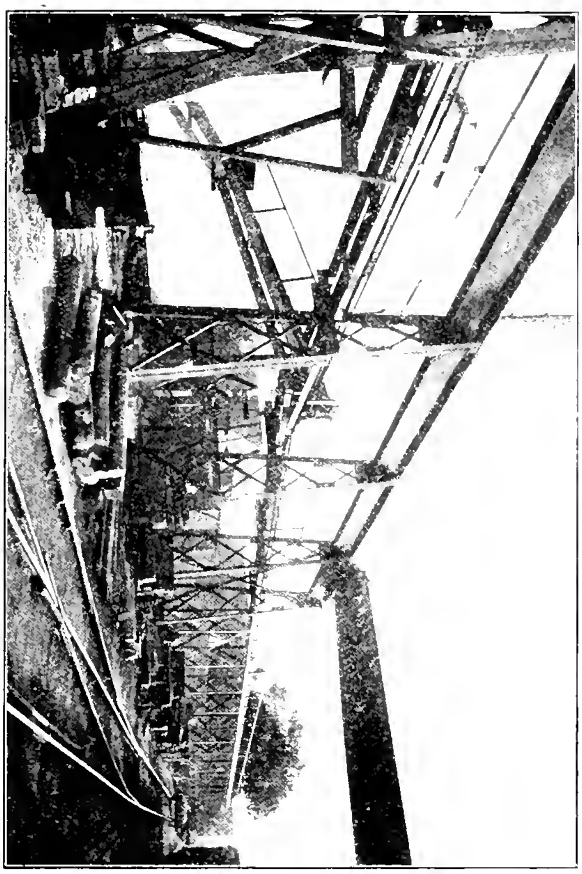


Fig. 3 — Conveyor System from Milling Building, Supplying Lines Running to Hammer and Drop-Shops.

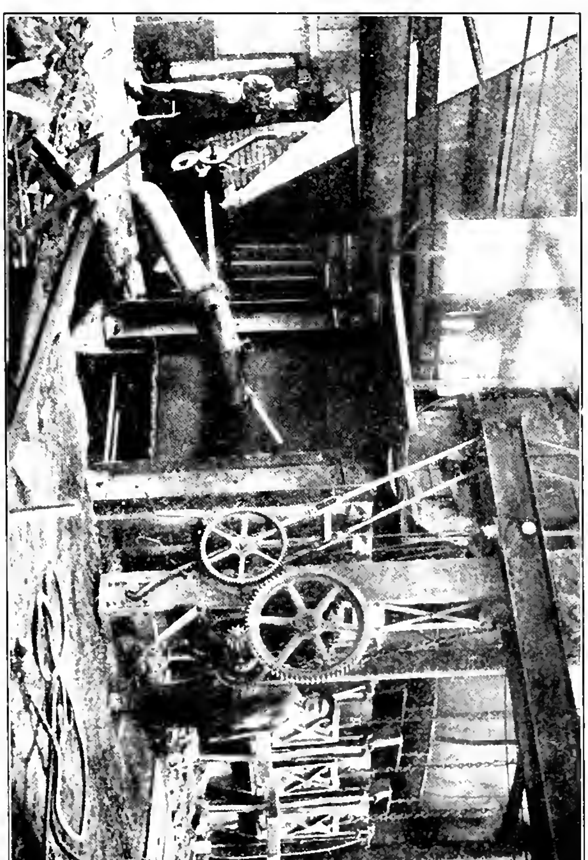


Fig. 4 — Three-Door Furnace with Waste-Heat Boiler, on which Tests were Run.

containing equipment for fuel oil or gas for industrial purposes. There has been no trouble whatever from spontaneous combustion, or fires from other causes, and there appears to be no reason to expect trouble from this source if ordinary precaution is used, as required with any other kind of fuel.

To insure the best results, the coal should be of high volatile and low ash and should be dried so as to contain not over ½ of 1 per cent of moisture, care being taken in drying to avoid overheating and so driving off any of the volatile content. The coal should be pulverized to a fineness that will permit 93 per cent to 95 per cent to pass through a 100-mesh sieve, and for some coal to the base of the hopper. By this method a continuous stream of coal passes the opening and any portion up to the capacity of the upper screw may be utilized by increasing or decreasing the cross jet, and as the lower screw has a greater capacity than the upper it is impossible to clog the device in case of stopping the consumption of coal altogether.

The furnaces in the drop shop are rebuilt oil furnaces and those in the hammer shop are rebuilt hand-fired coal furnaces, and it should be emphatically stated that it is a serious mistake to attempt to apply powdered coal to existing furnaces without rebuilding them in a manner best suited to that fuel, since rapid and eco-

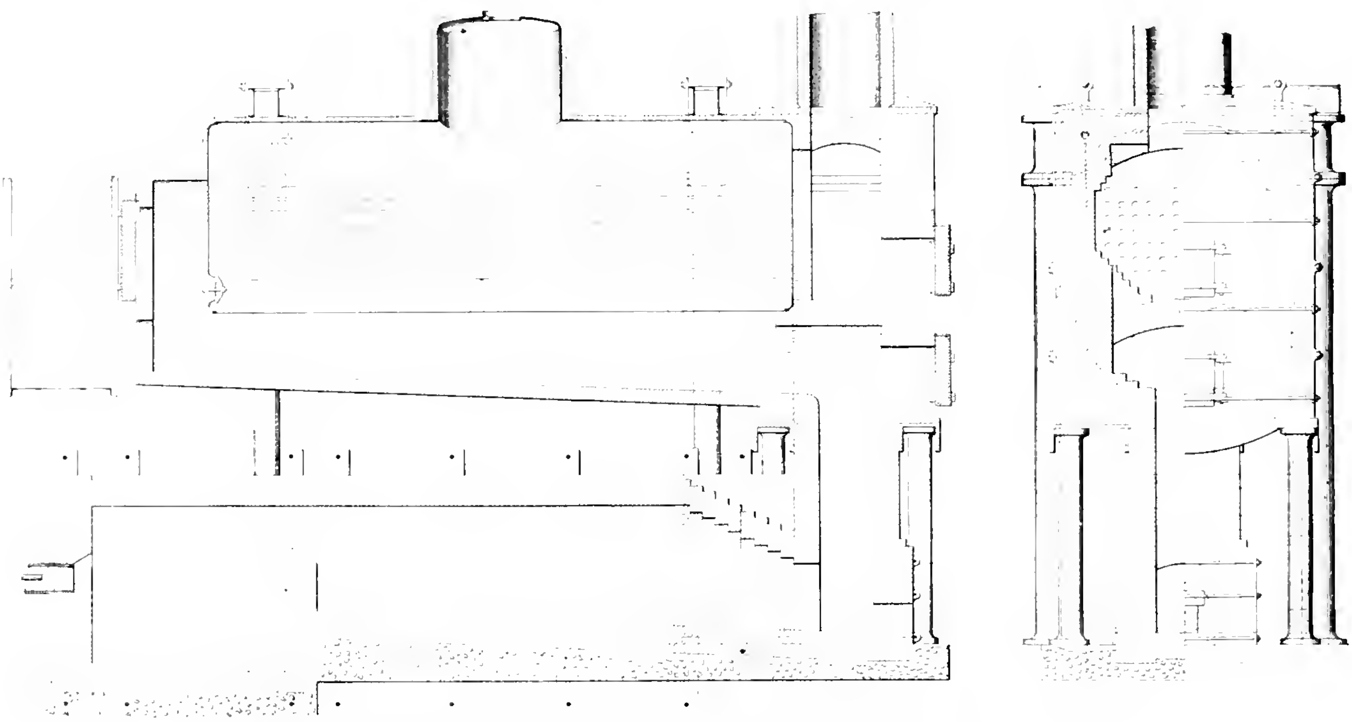


Fig. 5 Diagram of Three-Door Furnace with Waste-Heat Boiler, Shown in Fig. 4

classes of work even a greater degree of fineness has been found desirable.

In the burning of powdered coal, the fuel controlling device is the most essential element in the successful operation of the system as a uniform and controllable supply of the powdered coal must be supplied to the burner at all times. The controller used in this installation as shown in Fig. 9, was developed by the American Iron and Steel Manufacturing Company, and used successfully by them for seven years.

The device is motor driven and consists mainly of two screws, the upper located so as to propel the powdered coal from the bin forward to a point where it falls in a stream past an opening through which a cross current of low pressure air (a small portion of the total amount of air required for combustion) is directed, so as to force the desired quantity to the burner through suitable pipes. The lower or return screw is of greater pitch than the upper and returns the excess nomical operation, as well as the elimination of the ash, cannot be accomplished without properly designing the furnaces for the new fuel. Coal has been burned in this plant with an ash content as high as 18 per cent with uniformly good results, although the high ash causes considerable annoyance where open furnaces, such as used for heating small forgings, rods, etc., without doors are used or where doors are not wholly closed during operation, unless efficient hoods or an exhaust system for properly disposing of the small particles of escaping ash is installed.

The foregoing gives in a general way a description of the important features of the plant. After the first two furnaces were equipped in the drop shop and one in the hammer shop, tests were made to determine the savings effected with the use of powdered fuel as compared with fuel oil and hand-fired coal practice; and also as to what changes needed to be carried out in the alterations upon the other furnaces. The results of

the tests upon these first furnaces are here given.

TEST ON POWDERED COAL FURNACE NO. 3335

Nov. 12, 1913: Started 12 m., ran to 4:07 p.m. Heat in at 12:30.

Nov. 13, 1913: Started 6:15 a.m., ran to 12:50 p.m. Heat in at 7:28.

Furnace ran eleven heats, five heats of 10 pieces and 6 heats of 12 pieces. Worked on pedestal die wedge.

November 12

HEATS	TIME, MINUTES	FORGING TIME, MINUTES	PIECES
1	23	19	10
2	24	18	10
3	23	17	10
4	28	18	10
5	21	17	10

November 13

1	41	20	12
2	22	29	12
3	24	21	12
4	23	22	12
5	24	22	12
6	22	22	12

Actual time 10 hr. 22 min. Coal burned 2177 lb. Low-pressure blast 1 oz. from 8 in. pipe reduced to 6 in. at burner. High-pressure blast 8 oz. from $4\frac{1}{2}$ in. pipe reduced to $1\frac{1}{2}$ in. at controller and 2 in. leaving controller. Motor on controller $\frac{3}{4}$ h.p., 1.85 amp., 230 volts. 50-in. blower on low-pressure air runs 825 r.p.m., driven by 10 h.p. a.c. motor, 20-in. galvanized iron pipe connection.

The coal was measured as follows: Started with coal at a marked level in the hopper and after the test filled the hopper to the starting mark with coal weighed in bags, weight of bags subtracted.

COAL ANALYSIS

Ash	14.12
Volatile matter	20.28
Fixed carbon	64.60
	100.00
Fineness	98.4 per cent
B.t.u.	13,220

TEST ON OIL FURNACE NO. 5078

Nov. 14, 1913: Test started 6:10 a.m., ran to 3:35 p.m.

Furnace ran eleven heats, 12 pieces to each heat. Worked on pedestal die wedge.

HEATS	TIME, MINUTES	FORGING TIME, MINUTES	PIECES
1	31	18	12
2	25	18	12
3	20	16	12
4	21	19	12
5	23	18	12
6	21	17	12
7	40	22	12
8	28	16	12
9	21	16	12
10	23	17	12
11	31	16	12

Actual time 9 hr. 25 min. Oil used 1238 gal. Blast on oil burner $6\frac{1}{2}$ oz. from 6 in. pipe reduced to 4 in. at burner. 120 h.p. A. C.

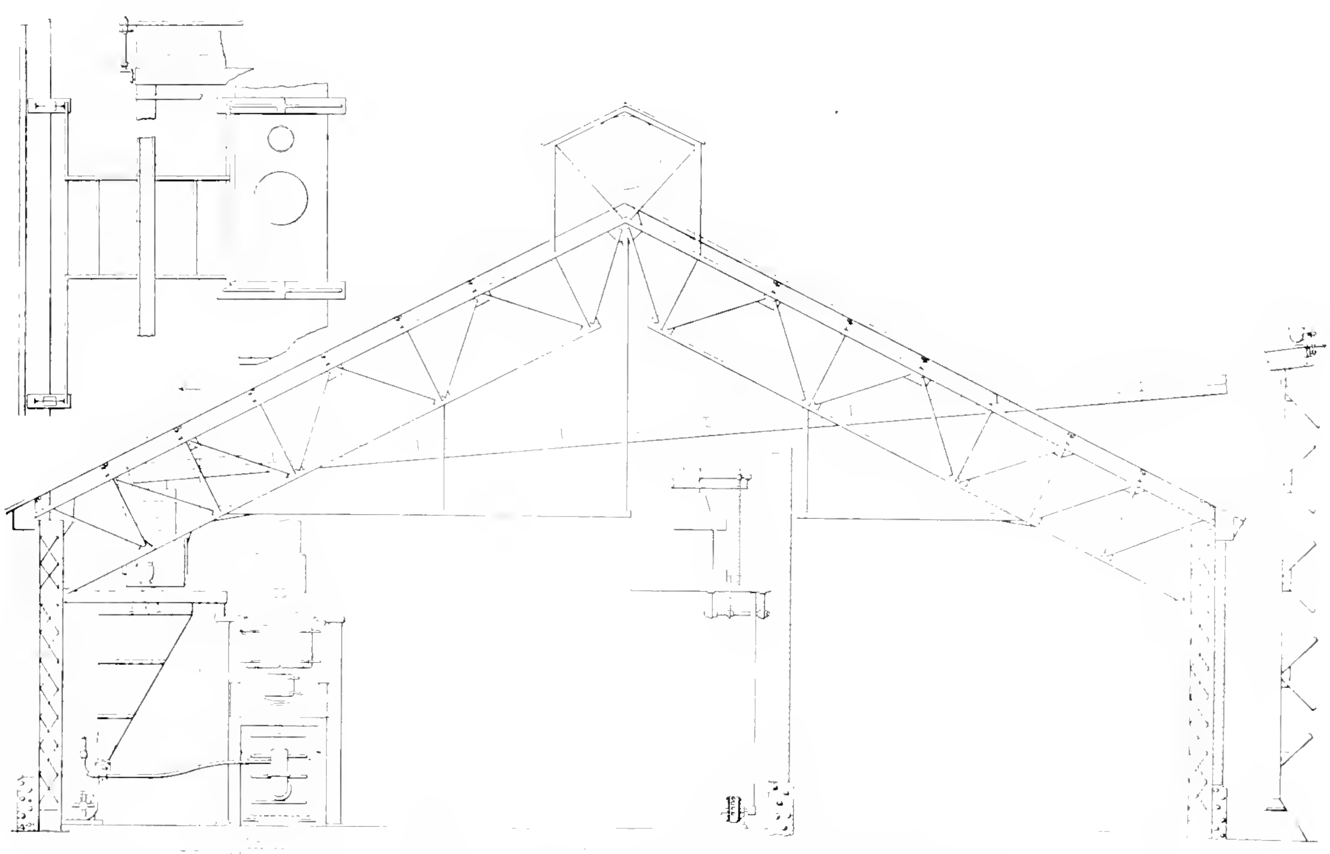


FIG. 6 CROSS-SECTION OF HAMMER SHOP SHOWING LOCATION OF CROSS CONVEYOR, SCALE, POWDERED COAL HOPPER AND THREE-DOOR HAMMER FURNACE

Motor runs three No. 10 Sturtevant Blowers for blast. Blast. $1\frac{1}{2}$ h p. per hr.

The oil was measured as follows: There were two tanks with gage glasses at the bottom, so that the exact level of oil could be determined; the tanks were so connected that one could be filled with oil while the other supplied oil to the furnaces. The tanks were accurately calibrated and the oil consumption computed accordingly.

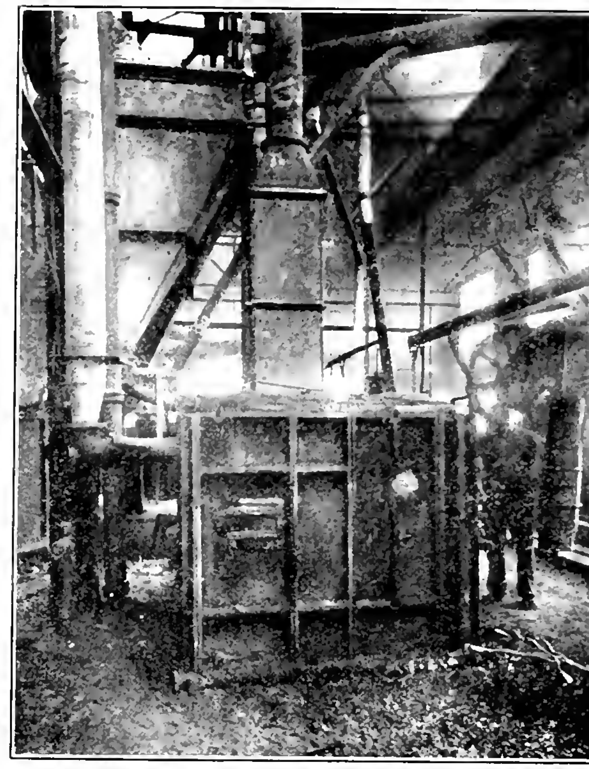
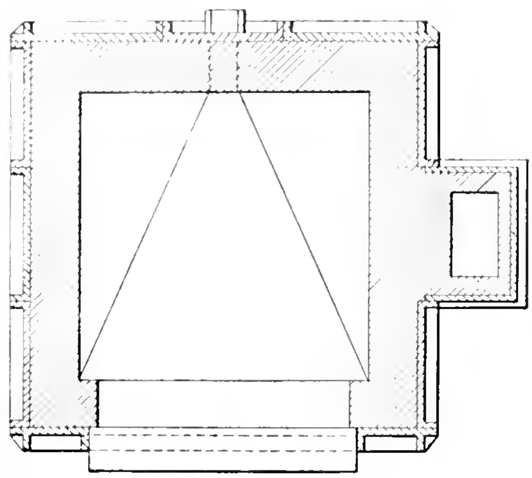


Fig. 7 Furnace Heating Blanks for Drop Forging on which Tests were Run



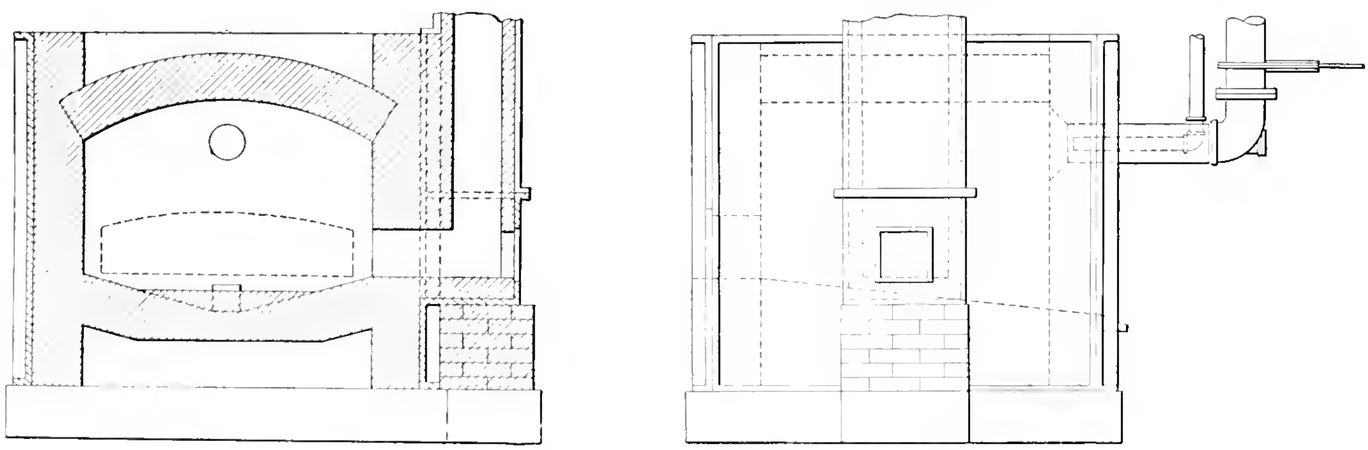


Fig. 8 Diagram of Furnace, Shown in Fig. 7

Comparison of Pulverized Coal Furnace No. 3335 and Oil Furnace No. 5078 (Both Same Size) in Drop Shop

	Pulverized coal furnace No. 3335	Fuel oil furnace No. 5078
Hours run	10 hr. 22 min.	9 hr. 25 min.
Fuel consumed	2177 lb. coal	138 gal. oil
Average time per heat	25.1 min.	25.8 min.
Average time per forging	1.87 min.	1.47 min.
Actual forgings	122	132
Forgings to be counted	132	132
Cost of fuel at contract price	\$2.82 (\$2.56 ton)	\$6.69 (1.8 ct. gal.)
Cost of fuel delivered to the furnace	\$3.31	\$6.89

The powdered coal furnace ran 57 min. longer than the oil furnace. However, 30 min. were lost because of failure to charge furnace on November 12 and 18 min. were lost on November 13, because plate for heating dies was not put in at the proper time.

The work was on pedestal die wedges, which are of iron. The blocks weigh 25 lb. and the forgings 16 lb. The time lost on the pulverized coal furnace would more than allow for making the 12 forgings, so that the amount turned out by each furnace should be considered equal as indicated in the table above.

Some weight should be given the fact that the oil costs were probably kept at a minimum, as the heater was thoroughly familiar with oil and was able to obtain the maximum heat with the minimum amount of fuel oil. The same men ran each furnace and the only fac-

tor of importance was that the ram used on the hammer at the oil furnace was about 500 lb. heavier than the ram on the hammer at the coal furnace. This did not affect the time of heats, but allowed a quicker forging time, and there was less time lost with nothing in the furnace.

It will be noticed from the coal analysis that the coal contained over 14 per cent of ash, which is too high for the efficient use of pulverized coal. The volatile matter analyzed low, but as this coal has been running above 30 per cent in volatile matter, it is believed there must have been some fault in the analysis.

The above results show the cost of operating the furnace on pulverized coal during these tests was 48 per cent of operating it on fuel oil at the present price.

In comparing the maintenance of the two styles of furnaces, the pulverized coal furnace had not been run long enough to make an accurate comparison, but indications are that the maintenance of the pulverized coal will not exceed that on the old style and will probably run less. The saving in labor with the pulverized coal furnace is shown to be:

Three men on ashes at $1.75	$5 25
Three men on fires nights at $2.10	6 30
Per 24 hours run	$11 55

Based on the shop running at average capacity there would be a labor saving of $11.55. This allows for men to start furnaces in the morning and wheel away ashes and slag.

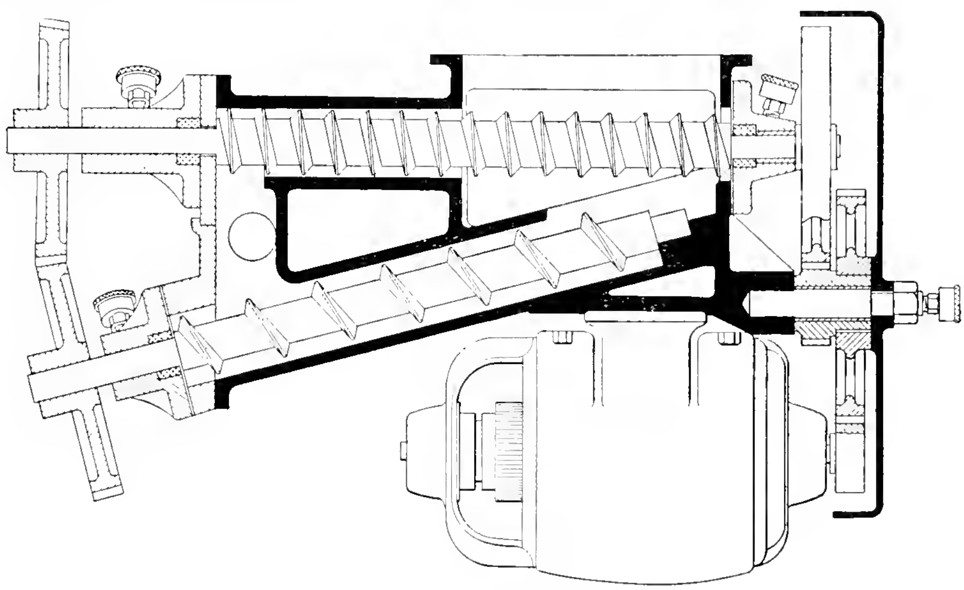


Fig. 9 Motor-Driven Controller

Comparision of Tests on Large 3-Door Forge Furnaces of Same Size Under Waste Heat Boilers Nos. 45 and 61

No. 45, old style furnace burning mine run coal, hand-fired. Nov. 12, 1913.

No. 61, new furnace equipped to burn pulverized slack coal. Nov. 21, 1913.

	BOILER NO. 45 MINE RUN COAL	BOILER NO. 61 PULVERIZED COAL
Hours run	10 hr. 5 min.	9 hr. 30 min.
Fuel consumed	4630 lb.	3200 lb.
Average time per heat	117 min.	120 min.
Cost of fuel actually delivered	$6.69	$1.14
Tonnage per furnace	9920	9920
Cost of milling, conveying and blast	$0.48	$1.04
Total cost of fuel burned	$7.17	$5.18
Cost per ton output	$1.45	$1.05

Both furnaces ran under favorable conditions and the men on both hammers turned out a fair average day's work. Both furnaces were on the same class of work and heated the same amount of material.

In comparing the coal the analysis given below shows that there is too high a percentage of ash in the slack coal; otherwise the samples are representative of the two grades of coal used.

Coal Analysis, Boiler No. 45

Sulphur	1.26
Ash	5.52
Volatile matter	29.17
Fixed carbon	65.31
B.t.u	13,826

Stack temperature 340 deg. fahr.
Blast on furnace $9\frac{1}{2}$ oz.

Coal Analysis, Boiler No. 61

Sulphur	1 27
Ash	13.72
Volatile matter	30.18
Fixed carbon	56 10
B.t.u	13,132

Stack temperature 240 deg. fahr.
Blast on fnrnace 1 oz.
Blast on coal 6 oz.

From these reports it will be noted that the air pressure required for burning powdered coal is materially less than that used on either oil or hand-fired coal furnaces. Owing to this decrease it was found necessary to lengthen the stack on the waste heat boiler to increase the draft and afford a better circulation.

TOPICAL DISCUSSION

Following the presentation of the papers upon Pulverized Fuel, there was a topical discussion for which contributions had been prepared by J. L. Agnew, W. P. Barba, H. G. Barnhurst, John V. Culliney, W. R. Dunn, William A. Evans, Edw. J. Kelley, A. W. Raymond. These contributions were sent to the Society in response to an invitation to furnish data upon the following selected topics:

(1) Grades of coal successfully used—analysis
(2) Experiences with coal high in ash and sulphur
(3) Essentials of storage bin for powdered fuel—troubles from storage
(4) Necessity for drying coal before grinding
(5) Fineness of grinding
(6) Cost of grinding and handling, including upkeep
(7) Danger from particles of dust floating in air
(8) Essentials of a good burner
(9) What troubles are likely to occur with burners in general
(10) Special features required in powdered fuel furnaces
(11) Air pressure used and effect of stack draft on combustion
(12) Experiences with ash or slag in furnace
(13) What temperatures are maintained in furnaces—influence of temperature on formation of slag
(14) Experiences with checkerwork in metallurgical furnaces
(15) Life of furnace as compared with furnaces using other fuels
(16) Items of expense or economy in the plant as a whole, due to use of powdered fuel

The contributions are as follows:

(1) *Grades of Coal Successfully Used—Analysis.*

A good average analysis of the coal used here is as follows:

Volatile matter	39
Fixed carbon	53
Ash	8
Sulphur	2
B t u	13,600

The amount of volatile matter present is probably of considerable importance, but we are not able to say from our own experience how high the fixed carbon could go and the coal still be successfully used in the powdered form, though it is stated that anthracite and even coke has been used.—J. L. Agnew.

The kinds we have used successfully are high-grade gas coals and gas slacks where the volatile has run about 35 per cent to 40 per cent, ash 6 per cent to 8 per cent and the sulphur low.—W. P. Barba.

Coal most suitable for kiln furnaces and other types of metallurgical furnaces is that which runs about 35 per cent in volatile combustible matter, 8 per cent or lower in ash, and 1½ per cent or lower in sulphur. Good results are being obtained, however, on coals which vary considerably from the above percentages.—H. G. Barnhurst.

The grade of coal successfully used in heating and puddle furnaces has a composition closely approaching the following:

Volatile matter	33
Fixed carbon	56
Moisture	1
Ash	9
Sulphur	1
	100

—John V. Culliney.

What is technically known as gas slack is the grade most generally used, particularly in the Portland cement industry. This is cheaper than run of mine gas coal, and in its fine state dispenses with the use of preliminary crushing machinery prior to going to the dryer. The coal should be high in volatile matter. Its range in this respect should vary from 28 per cent upward. The higher the volatile content, the more readily will the coal ignite, provided, of course, the fineness be the same. The volatile matter is driven off after the small percentage of moisture. It is readily ignited by the heat of the furnace, and, if the coal has been sufficiently reduced in fineness and properly mixed with air, the burning coal dust will approach the condition of an approximate gas. A typical analysis of a high-grade gas coal would be as follows, figured on a dry basis:

Volatile matter	34.50
Fixed carbon	57.00
Ash	8.50
Total	100.00
Sulphur	1.20

The value of a coal for a particular industry will depend greatly upon the character of the particular furnace and especially upon the material to be heated. For example, a coal high in sulphur may be used without deleterious effect in one industry, while in another it would cause a great deal of harm to the material being treated. Coals high in sulphur invariably give trouble, due to spontaneous combustion. This is especially true with some of the high sulphur coals of Indiana and Illinois.—W. R. Dunn.

Furnaces have been operated using coal with ash as high as 18 and 20 per cent, but the successful use of such coal is limited to those furnaces in which the deposit of ash on the charge of material does not seriously affect the product. For most furnaces of the rotary type and for heating furnaces, moderately good coal will do, that is coal containing 8 to 10 per cent ash. On furnaces for the more refined treatment of metals, such as the open hearth steel and copper refining furnaces, exact specifications should be enforced, limiting the ash to 3 or 4 per cent. Copper matt furnaces producing less refined copper than the above will stand a high percentage of ash. This ash, if deposited on the charge, is drawn off with the other slagged impurities. The one essential of coal for powdered coal burning is high volatile content. This should be above 20 per cent.—William A. Evans.

The type of furnace is the deciding factor in the choice of the coal. Following are two analyses which have given very satisfactory results in open hearth practice:

	No. 1	No. 2
Ash	10	5
Sulphur	1	½
Volatile matter	37	unknown
Moisture	1½	1
Cost per ton delivered	$2.50	$3.35

The following coal has been used for a period of about 10 years for heating annealing ovens:

Ash.	19.05
Sulphur	3.53
Volatile matter	24.62
B.t.u.	11,000

This coal was obtained for $1.70 delivered. Comparison of the above analyses will show the fallacy of predicting just what grades of coal can, and cannot, be burned. The consumer will have to decide for himself what coal will give the highest economy, and can probably arrive at no conclusion without actual tests. One user of the coal given in the second analysis has, after a period of 10 years of success with it, decided to change to a coal containing a much lower percentage of ash, and consequently higher calorific value. The reasons given are, less accumulation of ash in the furnace, and therefore the elimination of much of the expense of handling it, through the saving of the cost of pulverizing and otherwise preparing the useless ash, and that due to the higher calorific value of the fuel. This would seem to indicate that a more expensive coal containing less ash and having higher calorific value will decrease annealing costs; just how far this theory can be carried into actual practice depends on the local plant conditions and can probably be determined only by experiment.—A. W. RAYMOND.

(2) *Experiences with Coal High in Ash and Sulphur.*

The amount of sulphur present in coal used for reverberatory smelting is of little or no importance as the charge to the furnace always contains a large amount of sulphur. The ash, however, is of great importance. At different times we have used coal containing from 5 per cent to 10 per cent ash. When the coal is burned, part of the ash sticks at the throat of the furnace in a pasty condition, and when there is as much as 10 per cent ash, it tends to build up here and eventually interferes with the smelting. Usually, however, it can be kept barred off without much difficulty.

Another portion settles in a fine pulverulent condition in the flue chamber beyond the throat. This simply requires drawing out periodically with hoes through small side doors built in for that purpose. The amount obtained when burning about 70 tons of coal per 24 hours is 400 or 500 lb.

The greatest portion of the ash, however, settles on the bath in the furnace and forms part of the liquid slag. It is drawn off in that form and of course causes no difficulty whatever, only increasing somewhat the amount handled.

As coal ash is high in silica it is quite evident that a basic slag will combine with it most readily and in such a case the ash might be valuable as a flux. On the other hand, an addition of this high silica ash to a slag already high in silica might easily raise the melting point sufficiently to cause a good deal of trouble and interfere seriously with the working of the furnace.—J. L. AGNEW.

We find the ash rather troublesome, but this would not have been enough to condemn the coal had the price been low enough to warrant some extra trouble. In trying a gas slack of 12 per cent ash and 2 per cent to 3 per cent sulphur, we found trouble with both the ash and the sulphur, the latter throwing off very disagreeable fumes in the plant.—W. P. BARBA.

Coals running as high as 25 per cent ash, 5 per cent sulphur, have been used with success in cement manufacture.—H. G. BARNHURST.

The higher the percentage of volatile matter, the better the results obtained. In metallurgical furnaces the percentage of ash and sulphur should always be kept as low as possible, although the sulphur in the coal does not appear to be absorbed by the iron to any great extent; no more so than in the regular hand-fired puddle and heating furnaces. The ash causes very little trouble in furnaces maintaining a temperature of 2500 deg. fahr. or over, and in puddle and heating furnaces, having waste heat boilers located above them, part of the ash is deposited in the combustion chamber, part in the furnace proper, while the remainder is deposited beneath the boilers.

Very little ash passes up the stack. The ash deposited in the combustion chamber is removed by dropping the bottom or through the combustion chamber door. The bottom is made up of easily removable grate bars, upon which rests a layer of fine ash, which together with the furnace brick forms a pasty slag. This slag becomes hard and brittle when cool.

It is possible to remove this pasty slag through the combustion chamber door several times a day without difficulty and to clean this chamber entirely once a week, by pulling out the grate bars. The ash which is carried over the bridge wall runs off with the slag and the remainder of the ash is deposited under the boiler and removed at the end of each week.—JOHN V. CULLINEY.

In the cement industry, a coal high in ash may increase the formation of clinkers, particularly if the raw materials fed to the kiln are deficient in silica. Otherwise, a coal having a high percentage of ash causes only a slight inconvenience, due to the removal of larger quantities of fine ash from the dust settling chambers. In some cases where the ash has a low fusing temperature, trouble may be caused by the formation of an excessive amount of slag. Generally the presence of sulphur in large or small percentages is the cause of a great many difficulties.

Where the coal is used in drying furnaces, such as rotary dryers, the presence of sulphur in the coal will cause no ill effects, but where powdered coal is used to reduce nickel ores, copper ores, etc., especially in the refining end of the industry, the question of sulphur in the coal should receive careful attention. It has been claimed that if the sulphur in the coal is first burned off to the dioxide form SO_2, there is very little danger of it combining with a molten mass of metal having a strong affinity for sulphur. If, on the other hand, the powdered coal is not supplied with the requisite amount of air causing incomplete combustion and burning the sulphur to the monoxide form SO, there is a great tendency of the sulphur to unite with the molten metal, particularly so because it is present in an atmosphere of CO and free carbon, and has no chance to take on more oxygen. I believe that even where there is great danger of sulphur absorption, a furnace can be constructed so that little or no sulphur in the coal will unite with the metal in the furnace, that is, the sulphur will be burned to sulphur dioxide and there will be an oxidizing rather than a reducing flame.—W. R. DUNN.

High ash coal often introduces insurmountable difficulties. The ash accumulates so rapidly in the combustion chamber and clings so tenaciously to the walls that it is almost impossible to remove it.—W. A. EVANS.

The presence of sulphur in the coal is important only as it affects the material treated in the furnace. In this case a coal of low enough sulphur content must be used to keep the sulphur content in the finished product below the maximum allowed by specification. The relation of the sulphur content in the finished product to that in the fuel is about the same in the case of pulverized coal as of producer gas.—A. W. RAYMOND.

(3) *Essentials of Storage Bin for Powdered Fuel—Troubles from Storage.*

Our storage bins hold about 60 tons of powdered coal and are kept practically full all the time. The dust will take fire very easily, even a lighted match often being enough to ignite it, but it simply smolders away harmlessly. The best way in such a case is to shut off the supply of fresh coal and use up what is already in the bin.—J. L. AGNEW.

The sides of the storage bins should be of very sharp slope in order to have the coal flow freely. It has been apparent that more clogging takes place if the moisture is allowed to go over 1 per cent than if it is kept below. Probably the interior smoothness of the bins has much to do with the coal flowing down as required. A great deal of moisture will form in the first bin in which the coal is stored after drying, if the time of storage is long, the moisture often running down through the coal and dripping out at the bottom of the bin. In the bin where the pulverized coal is stored we have found by experience that by the end of 96 hours combustion is likely to take place; and also that such has occurred in several cases in less than that length of time.—W. P. BARBA.

It is advisable, in storing large piles of coal, to have the coal under roof, with at least two sides of the building open, in order to allow part of the moisture to evaporate, thereby lessening the work of the dryer.

Pulverized coal which is damp should never be stored for any great length of time, as spontaneous combustion is likely to occur. Dry coal can, however, be stored indefinitely.

All hoppers to hold pulverized coal should be made with two sides vertical and the other two sloped, at an angle of about 30 deg. with the vertical. This is done to prevent the coal from arching. The greater the percentage of moisture in the coal, the greater the tendency to arch.—JOHN V. CULLINEY.

A good storage bin for powdered coal should be free from pockets or corners where the coal is likely to lodge and remain stored for some time. Powdered coal stored for some length of time is apt to ignite, due to spontaneous action. The bin should be of ample capacity, not too large, and should hold coal sufficient for 12 to 18 hours' use. It should be covered with a sheet iron cover to protect the feeding mechanism against foreign matter falling into the bin and getting into the working parts of the feeder; a cover also prevents the accidental introduction of sparks or fire. It should by all means be constructed of fire resisting material. Sheet iron bins are very serviceable, especially when the coal stored is in a dry condition and not allowed to absorb moisture from the air. Wet coal, if it contains a large amount of sulphur, generally causes rapid corrosion of the sheet metal plates. Dry powdered coal is exceedingly hygroscopic and it is necessary that the coal in the bin should be kept as free as possible from contact with the atmosphere of the room.—W. R. DUNN.

The bin should be of a size to carry over 14 or 16 hours without refilling, thus giving plenty of time for such repairs as may be required without shutting down the furnace. It also permits of operation of grinding plant during the day, giving enough storage to carry through night service. The only trouble that can come from storage of powdered coal is spontaneous combustion, when coal is allowed to stand too long in bins. Powdered coal should always be kept moving, not allowed to stand more than one day in case of a temporary shut-down of plant. For any greater length of time, the powder should all be drawn out of the bins. Spontaneous combustion is more likely to take place with powdered coal than with ordinary slack because of the heat accumulated during the grinding.—WILLIAM A. EVANS.

The essentials are proper capacity and shape of bin. The capacity should be large enough to permit of sufficient coal storage to carry the furnace operation through any shut-down which may occur in the grinding room. With the proper equipment a 24 hour storage is generally sufficient and absolutely safe. Pulverized coal when properly prepared has been stored without any occurrence of fire for periods of from a week to ten days. Storage for such a long time as this can only be accomplished without fire danger if the coal is delivered to the bins in a thoroughly dry condition and at a comparatively low temperature.

The bins should be made and kept as airtight as possible. A very frequent difficulty experienced in the storage bin is a tendency for powdered coal to bridge over at the bin outlet, and consequently stop flowing into the feeder. Such a condition is sometimes very hard to overcome. One very large and successful user of the fuel claims to have eliminated this annoyance by a peculiar construction of the bin. The ordinary cone shaped hopper is replaced by a trough of triangular cross-section and a small conveyor is run directly through the coal along the bottom of the trough. This conveyor can replace the one generally used to control the amount of coal fed to the furnace, and the equipment consequently becomes as simple and inexpensive as the one previously used.—A. W. RAYMOND.

(4) *Necessity for Drying Coal before Grinding.*

Coal as received runs from 4 per cent to 8 per cent moisture, which should if possible be reduced to 1 per cent or less. This is not an easy matter. A small lump of coal may be ignited on the surface and still not be dry throughout. Moisture is detrimental because (*a*) it reduces the capacity of the grinders, (*b*) it tends to pack in the storage bins, (*c*) it lowers the possible attainable temperature, and (*d*) it lessens the efficiency.—J. L. AGNEW.

It is essential to have the coal dried to at least 1 per cent of moisture, both for the ease of pulverizing as well as for ease of screening in the pulverizer.—W. P. BARBA.

Where high temperatures are required, a higher degree can be obtained by the use of dried rather than wet coal, as the temperature of combustion will decrease with the increased percentage of moisture. For instance, a coal containing 3 per cent moisture, as it frequently does, if passed through a drier would give approximately a temperature of 3200 deg. fahr. when burned with 25 per cent excess air, whereas the same coal containing 10 per cent moisture would give only 3000 deg. when burned with 25 per cent excess air. In ad-

dition to the above, wet coal clogs the screens of certain types of pulverizers considerably, decreasing the output of the pulverizers and also affecting its quality. Wet coal will stick in bins and in burners.

Coal should be dried to 1 per cent or less before pulverizing, if possible.—H. G. Barnhurst.

If it is desired to obtain conditions such that the coal will ignite instantly, the moisture content should not exceed one-half of 1 per cent. The coal on its way to the furnace, after it has been dried, absorbs additional moisture, and by the time it is ready to be used it may contain as much as 0.7 of the 1 per cent moisture. Dry coal is desired because it can be more intimately mixed with the air and fed more regularly to the furnace. Wet coal or damp coal will clog the feeding mechanism and ejector tubes, and in addition to this, it is apt to form coke in the furnace and the furnace temperature will not be so high as when dry coal is used.—W. R. Dunn.

The necessity for drying coal is controlled by two factors, the design of the grinding machine and the capacity of the plant. The first factor concerns machines that depend upon screens for regulating the fineness of the coal. Where screens are used coal must be dried. With moist coal screens clog up. Machines that depend upon air separation for regulating the fineness of coal have no such difficulty. They do, however, consume more power when grinding moist coal.

The other factor, viz. capacity of plant, is important as it has also to do with economy in building a small plant. Where but 20 or 30 tons a day are to be used it is possible so to select coal as to keep its moisture down to under 5 per cent. This can be secured by shipping in boxed cars and carrying in dry storage a sufficient quantity to last ten days or two weeks. Where large quantities are used and where it is impossible to carry enough storage to insure a continuous supply of commercially dry coal a dryer is absolutely necessary.

It will be argued that there are plants using coal that has not been dried. Where this is done in large quantities it will be found that the same plant has other furnaces or other means of using up the wet coal that comes to the plant and is able to select the driest for use in the machines in question. The writer has used coal containing 20 per cent moisture. Although it is possible to struggle through for a short time under this condition, it is so troublesome that it can be put down as a good rule as not possible. Wherever undried coal is used it is in the direct delivery system, where the coal is fired direct from the pulverizer to the furnace. The storage system will not work on moist coal; caking and arching of the coal in the bins interrupts the uniformity of feed.—W. A. Evans.

Burning wet coal introduces moisture or steam into the furnace, where its presence is always sure to prove a hindrance to efficient combustion, and consequently prevent the attainment of highest economy.

Coal containing more than 1½ per cent of free moisture will require more horsepower when being pulverized, and the pulverized product will contain a much lower percentage of impalpable powder. Therefore, it is axiomatic to say that drying the coal will prove economical.—A. W. Raymond.

(5) *Fineness of Grinding.*

The finer the coal is ground the more complete will be the combustion. The standard practice of 95 per cent to pass through a 100-mesh screen, and 80 to 85 per cent to pass through a 200-mesh screen is good practice, and one to which we endeavor to adhere.—W. P. Barba.

It is customary in the cement industry to grind coal to such a degree of fineness that 95 per cent will pass through a 100-mesh screen. The finer the coal the greater its moisture absorbing properties. Fine coal is also more liable to spontaneous action than the same coal more coarsely ground. —W. R. Dunn.

Standard practice was for some time to attain a fineness such that 90 per cent would pass through a 100-mesh screen. This has gradually been increased to a present standard of 95 per cent through a 100-mesh screen; with 80 per cent passing a 200-mesh screen. Finer grinding would be very desirable except for the much increased cost for power.—W. A. Evans.

It is generally accepted that coal which contains less than 95 per cent of material which will pass a 100-mesh test sieve and less than 82 per cent which will pass a 200-mesh sieve cannot be burned with the highest efficiency of combustion and the greatest economy. In direct contradiction to this is the experience of one of the oldest users of the fuel in annealing ovens. In this particular case the coal is pulverized so that only 60 per cent will pass a 100-mesh sieve and only 37 per cent will pass a 200-mesh sieve.

It is futile to expect a decrease in the cost of fuel by pulverizing coarser than 95 per cent through the 100-mesh sieve. I think it will be agreed that coal must contain no particles which will not pass through a 40-mesh sieve, and when this requirement is met there will always be at least 95 per cent of 100-mesh goods in the finished product. Consequently an attempt to pulverize coal so that it will all pass a 40-mesh sieve and, at the same time, contain less than 95 per cent which will pass a 100-mesh sieve, means the addition of special machinery whose maintenance cost is high and there is therefore no gain in economy in the preparation of the coal. As we cannot reasonably expect a coarse degree of pulverization to show any added efficiency in the furnace over a finer degree, there is no hope of obtaining higher economies by pulverizing coarser than 95 per cent through a 100-mesh. In fact, if the proper equipment is used it will be found less expensive to produce a coal containing 95 per cent of 100-mesh goods and from 82 to 85 per cent of 200-mesh goods, than that of any other fineness.

As for coal of a higher degree of fineness, we can undoubtedly expect a higher efficiency of combustion and there will also be less annoyance from the ash, due to the fact that it is in a more finely divided state. To offset this, on the other hand, there is the added cost of preparation.

I believe the only way the question can be answered satisfactorily is by experiments with coals of various finenesses. From my knowledge of pulverizing costs I can say that the degree of pulverization can be absolutely limited to 98 per cent through the 200-mesh. This degree can be attained with a comparatively small increase in preparation, but to go further increases the cost excessively. All that we know at present are the limits of the field in which to investigate,

viz: the coal must contain not less than 95 per cent through the 100-mesh and not more than 98 per cent through the 200-mesh.—A. W. Raymond.

(6) *Cost of Grinding and Handling, including Upkeep.*

The average cost of grinding and delivering the coal to the furnaces is about 45 cents per ton, and is made up as follows:

	Cents
Labor	15
Power	10
Repairs	14.5
Coal for drying	5.5
	45.0

These figures represent an average for 5 months from April to August, 1913.

The item "repairs" includes all repairs to coal crackers, grinders, conveyors, fans, belting, etc. Three men on one 10-hour shift are all that are necessary to prepare and deliver 70 or 80 tons to the furnace per day.—J. L. Agnew.

The cost depends largely upon the amount of coal operated upon. Based on 200 tons in 24 hours, with coal at $1 per ton and same coal being used for power, the expense would be, fuel for drying the coal, power, labor, supplies and repairs, approximately 17.6 cents per ton; at $2, about 21.8 cents per ton; at $3, about 23.9 cents per ton. These figures, however, do not include overhead charges, interest or depreciation—in other words, the cost of preparing depends upon the quantity to be pulverized, as well as cost of labor, power, etc., entering into the operation. Repairs to driers and mills should not exceed 2 cents per ton, and the power required for this operation should not exceed 17-h.p-hr. per ton.—H. G. Barnhurst.

In a mill having an average output of 150 tons per day, the cost is about 40 cents per ton.—John V. Culliney.

The figures given herewith are taken from a plant capable of grinding 140 tons of coal per 24 hours. As the plant was built about 16 years ago, it contains more refinements and larger storage space than is considered good practice to-day. The average cost per ton of 2000 lb. for pulverizing coal (including interest on investment, 5 per cent for depreciation and 5 per cent for obsolescence) is:

	Cents
Labor operating department	15.64
Labor repairs to machinery	1.70
Supplies, fuel, power, etc	14.71
Oils and waste	1.25
Repairs	4.54
	37.84
Interest, depreciation and obsolescence	1.35
Total	39.19

—W. R. Dunn.

The cost is very well established to be between 40 and 45 cents per ton, which, when replacing mine run coal, is just about taken care of by the possible use of slack coal at 50 cents per ton less than what the mine run costs.—W. A. Evans.

The cost will vary with the local plant conditions, the variable factor being, of course, the cost of handling. The pulverizing cost naturally depends upon the degree of pulverization, and the amount of coal consumed. Table 1 will give some idea of how this cost varies, and form a basis on which to calculate this cost for any particular installation. The figures are applicable only when the Raymond system of pulverizing is used, and are obtained from actual experience covering a period of over five years. Table 2, from the Ruggles-Coles Engineering Company, will be of service in calculating drying costs.—A. W. Raymond.

TABLE 1 COST FOR PULVERIZING COAL

Capacity of Grinding Room, Tons per Hour	Percentage through 100 Mesh	Percentage through 200 Mesh	H.P. at ¾c. Kw-Hr: Total H.p. Required	H.P. at ¾c. Kw-Hr: Hours per Ton	H.P. at ¾c. Kw-Hr: Cost per Ton	Labor: Men at $2 per Day	Labor: Cost per Ton	Cost per Ton for Maintenance	Total Cost per Ton
1	99	95	45	45.0	22.5	1	20.0	6.66	49.16
2	95	82	45	22.5	11.25	1	10.0	3.33	24.58
2	99	95	60	30.0	15.0	1	10.0	3.40	28.40
3	95	82	60	20.0	10.0	1	6.66	2.22	20.88
3	99	95	85	28.0	14.0	1	6.66	2.40	23.06
4	95	82	75	19.0	9.5	1	5.0	1.70	16.20
5	95	82	85	17.0	8.5	1	4.0	1.20	13.70
6	99	95	170	28.0	14.0	1	3.33	2.40	19.73
10	95	82	170	17.0	8.5	1	2.0	1.20	11.70
10	99	95	255	28.0	14.0	2	4.0	2.40	20.40
25	95	82	425	17.0	8.5	2	1.7	1.20	11.40
25	99	95	680	28.0	14.0	3	2.4	2.40	18.80

TABLE 2 FUEL REQUIRED TO DRY COAL

Percentage of Moisture in Coal	Coal Consumed per Hr. in Lb. in Operating Dryer*: 160	230	350	540	715	900
	Capacity of Drier in Tons per Hr.					
1	19.5	28.1	43.2	66.8	88.9	113.0
2	15.3	25.1	33.5	51.8	68.9	86.3
3	12.7	18.2	27.5	42.4	56.4	70.6
4	10.7	15.5	23.6	36.4	48.4	60.6
5	9.3	13.3	20.3	31.3	41.6	52.2
6	8.1	11.7	17.7	27.4	36.4	45.7
7	7.2	10.4	15.7	24.1	32.1	40.2
8	6.5	9.4	14.3	22.0	29.3	36.7
9	5.9	8.5	12.8	19.8	26.4	33.0
10	5.4	7.8	11.8	18.4	24.4	30.4
11	5.0	7.1	10.8	16.7	22.2	27.8
12	4.6	6.6	10.0	15.3	20.2	25.2
13	4.2	6.1	9.3	14.4	18.9	24.0
14	3.9	5.7	8.6	13.3	17.7	21.9
15	3.7	5.3	8.0	12.3	16.3	20.2

* Coal to have 14,000 B.t.u. per lb.

(7) *Danger from Particles of Dust Floating in Air.*

The grinders, conveyors and bins are all enclosed and very little dust escapes. We have used open fires continuously in the building where the grinding is done and never have had an explosion or an accident of any kind due to dust in the atmosphere.—J. L. Agnew.

There is a real danger from dust and particles of powdered coal suspended in the air. Consequently, we have the building in which the pulverizing is done largely open at the bottom and open louvers at the top. Also we make

it a practice to keep the plant clean and free from accumulations of loose dust.—W. P. BARBA.

Only when floating or mixed with air will pulverized coal puff or explode, if ignited. Explode, however, is too strong a term to use unless large quantities are involved, in which case the progressive rise in temperature and heat during the puff might increase the violence to an explosive degree. Coal being carried from pulverizers to bins should be handled as a solid material, and not in the shape of a dust cloud, since any firing would engage the whole volume. Aerial propulsion for transfer of pulverized coal should be avoided. Leakage should be guarded against to prevent dirt or accumulations in inaccessible places. Explosions occur only when the mixture of air suffices to supply oxygen enough to support combustion. A pulverized coal plant should be kept clean, and it can be. Accumulations of dust on beams or projections when dislodged may in theory make an explosive mixture with the air, but such explosions are rare. Explosion is only combustion intensified. It is only through carelessness that any explosion in the handling of pulverized coal could occur to-day.—H. G. BARNHURST.

Coal dust is dangerous only in a suspended state, that is, surrounded by sufficient air to cause instant deflagration. Many pulverized coal plants will be found that have coal dust floating around in the air, surrounding the pulverizing machinery. There is, however, no excuse for this, since a pulverizing equipment may be compared to a steam plant. If a steam boiler can be kept from leaking under a pressure of 100 lb., surely a pulverizer can, in which there is practically no pressure.—JOHN V. CULLINEY.

There is always danger of fire from particles of any kind of dust floating in air in a confined space if fire or sparks are allowed in that space. In the case of powdered coal there is no excuse for dust escaping except in the grinding room, which is bound to be somewhat dirty. The protection is to insist upon no sparks or fire in the grinding room. Danger is absolutely eliminated in the case of the direct delivery system, for there is then no powder escaping.—W. A. EVANS.

Coal dust which is finer than 200 mesh may be considered extremely dangerous. Very finely divided particles are liable to ignite spontaneously. Coals which ignite below a temperature of 150 degrees within one hour are dangerous. The liability of coal dust to ignite spontaneously is dependent upon the temperature of self-ignition and the time of heating necessary, and increases in proportion to the percentage of oxygen present in the coal.

Coal dust which is suspended in air can be ignited without the presence of inflammable gas. The presence of moisture lessens the probability of explosion, and therefore dust should be dampened with sprinklers. The use of stone dust has been suggested for preventing explosions, but its value in that connection is doubtful.

Coal dust containing any uncombined hard material, like silica, is very dangerous to health, usually producing a fibroid condition of the lungs.

In plants where particles of dust are floating about in the air, it is advisable therefore to use the following precautions: (*a*) permit no smoking; (*b*) prohibit the use of matches; (*c*) do not use naked gas lights; (*d*) have no girders or open beams on which the coal dust may possibly lodge; (*e*) use only incandescent electric lamps for lighting; (*f*) be sure that all machinery, floors and walls are kept clean; (*g*) prevent the escape of dust by providing a short and direct discharge to the furnace.—EDWARD J. KELLEY.

When the atmosphere in the grinding room becomes impregnated with coal dust, a condition exists which may result in a very serious explosion. This is, practically, the only danger which occurs in the handling of pulverized coal, and it is entirely eliminated by the use of equipment in which the coal can be prepared without allowing any dust to leak out and permeate the surrounding air in the room. —A. W. RAYMOND.

(8) *Essentials of a Good Burner.*

Only one type of burner (Fig. 1) has been used here. It has given no trouble. One essential of a good burner is that the air and coal supply must be under complete control.—J. L. AGNEW.

The essentials are regular feed, ease and accuracy of control and regulation. If these requirements are complied with in any type of burner, it should be satisfactory.—W. P. BARBA.

In a good burner there should be absolute control over the flow of pulverized coal to the burner pipe. In other words, it should be so devised that the clearance around the screw, or other means of transfer, should be small, so as to prevent any rush of coal by vacuum formed by blower in the burner pipe. Pulverized coal when mixed with air flows easily. There are a large number of so called burners on the market which are in reality fuel controllers, and do not have anything to do with the actual burning of the fuel. In other words, they feed the coal to the burner pipe only. In burning pulverized coal absolute control must be had for regulating the quantity of air for controlling the temperatures.—H. G. BARNHURST.

The essentials are: (*a*) uniform feed, (*b*) proper mixture of coal and air, (*c*) proper control; ability to vary coal supply, (*d*) simplicity, (*e*) compactness.—JOHN V. CULLINEY.

A burner should thoroughly and intimately mix the coal dust and air. It should feed the coal with absolute uniformity to the furnace to which it is attached, and be so constructed that the air or blast pressure can be varied to suit the requirements. The feeding mechanism should respond instantly to the demands made upon it by the operator. All parts should be accessible and readily removed for renewals and repairs with very little inconvenience, and be so proportioned that the velocity of the coal leaving the burner is not excessive. It should be capable of burning coal to within one-half inch of the extreme burner tip, and so constructed that the tendency to choke up is reduced to a minimum. Should such choking occur, due to the accidental introduction of foreign matter, it should be so made that it can be readily cleaned.—W. R. DUNN.

The difficulties in the way of obtaining easily the essentials of uniform feed of both air and coal, thorough mixture of the

two, and exact control of both, have been the tendency of powdered coal to flush through any opening uncontrolled and also to cake and to arch over at the point of delivery from storage hopper.

There are two general types of powdered coal burners in use, those depending upon varying the speed of a screw conveyor for control, and upon varying the quantity of air blowing through a stream or small mass of coal. The control by air rather than that by screw conveyor of variable speed seems to work out to the best advantage, for the reason that any speed control is bound to be bungling and not of sufficiently fine adjustment. On the other hand, the quantity of powder picked up by a blast of air in passing through either a falling stream of coal or forcing its way through a small body of the powder has a constant ratio to the air blast and is subject to very exact control. A good burner should operate within 3 per cent variation in quantity of coal for any number of 5-minute intervals for any given setting of its controller. In the case of the air control the blast of air operating at about 6 oz. picks up more coal than it can furnish with oxygen, so additional air has to be provided for combustion. Two air blasts are therefore provided, one for control of the quantity of coal and for conveying the coal from the controller up to the furnace. The other air supply is for furnishing the additional amount of air for combustion, usually at about 1/2 oz. pressure.—W. A. Evans.

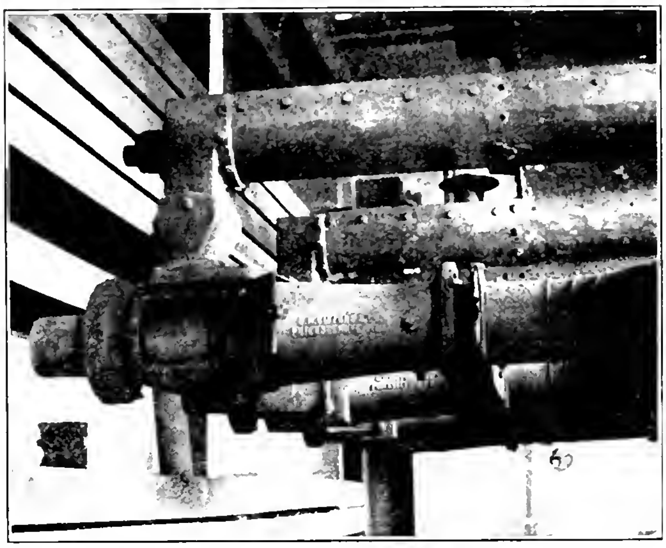


Fig. 1 Burner used in Metallurgical Furnace

Fig. 2 Inside of Reverberatory Furnace, looking toward the end at which the Pulverized Coal is Introduced

The supply of coal should be absolutely under control, and the mixture of the coal in the air uniform. There are several burners on the market which very nearly approximate this result. They are either of the syphon type, in which the supply of coal is controlled by air suction, or the more common screw conveyor type, which depends on a variable speed screw for regulating the flow of the coal. One very good way to insure a uniform mixture of coal and air is to make the coal dust travel through a horizontal pipe at least 6 or 8 ft. long, after it is fed to the air and before entering the furnace. —A. W. Raymond.

(9) *What Troubles are Likely to Occur with Burners in General.*

Stoppage of the burner is the usual trouble, which may be caused by small foreign substances and occasionally by the powdered coal arching over in the bin, due possibly to dampness or other causes, and then falling with a sudden avalanche effect, which, in some cases, stops the burner or blows a fuse, and in other cases sends a heavy charge into the furnace and the powdered coal which cannot be burned forms a heavy smoke.—W. P. Barba.

No troubles should occur with burners of proper design, if the coal is thoroughly dried and properly pulverized.—H. G. BARNHURST.

The troubles found with most controllers are: (*a*) inability to mix coal and air properly, (*b*) irregular feed, (*c*) choking up, and (*d*) inability to control for small furnace use.—JOHN V. CULLINEY.

Intermittent and non-uniformity of feed, choking up of air passages, the accumulation of foreign matter in the interior of the burner to high velocity through the discharge pipes, and unreliability of feeding device are troubles that may occur.—W. R. DUNN.

The troubles that can occur are interruptions from caking and arching over as previously spoken of and the flushing of coal through openings and along screw conveyors if used as part of the burner. Uniformity of feed is also possible of some improvement. These troubles are entirely overcome by the use of a direct delivery system where the control is all obtained, while the coal is still coarse and easily kept within control. Burners must be placed within 5 ft. of the furnace, for otherwise the coal will settle out from the air and the thorough mixture will be disturbed.—W. A. EVANS.

(10) *Special Features Required in Powdered Fuel Furnace.*

No special features need be introduced in a reverberatory furnace to make it suitable for use with pulverized coal. All that is necessary is to omit the usual firebox entirely and extend the bridge wall to the roof. Holes of course will be left in the bridge wall for the burners to pass through. Fig. 2 shows the inside of a reverberatory furnace before being put into commission looking towards the end at which the pulverized coal is introduced.—J. L. AGNEW.

A proper distance between the burner and a bridge wall must be designed so that combustion may take place, the

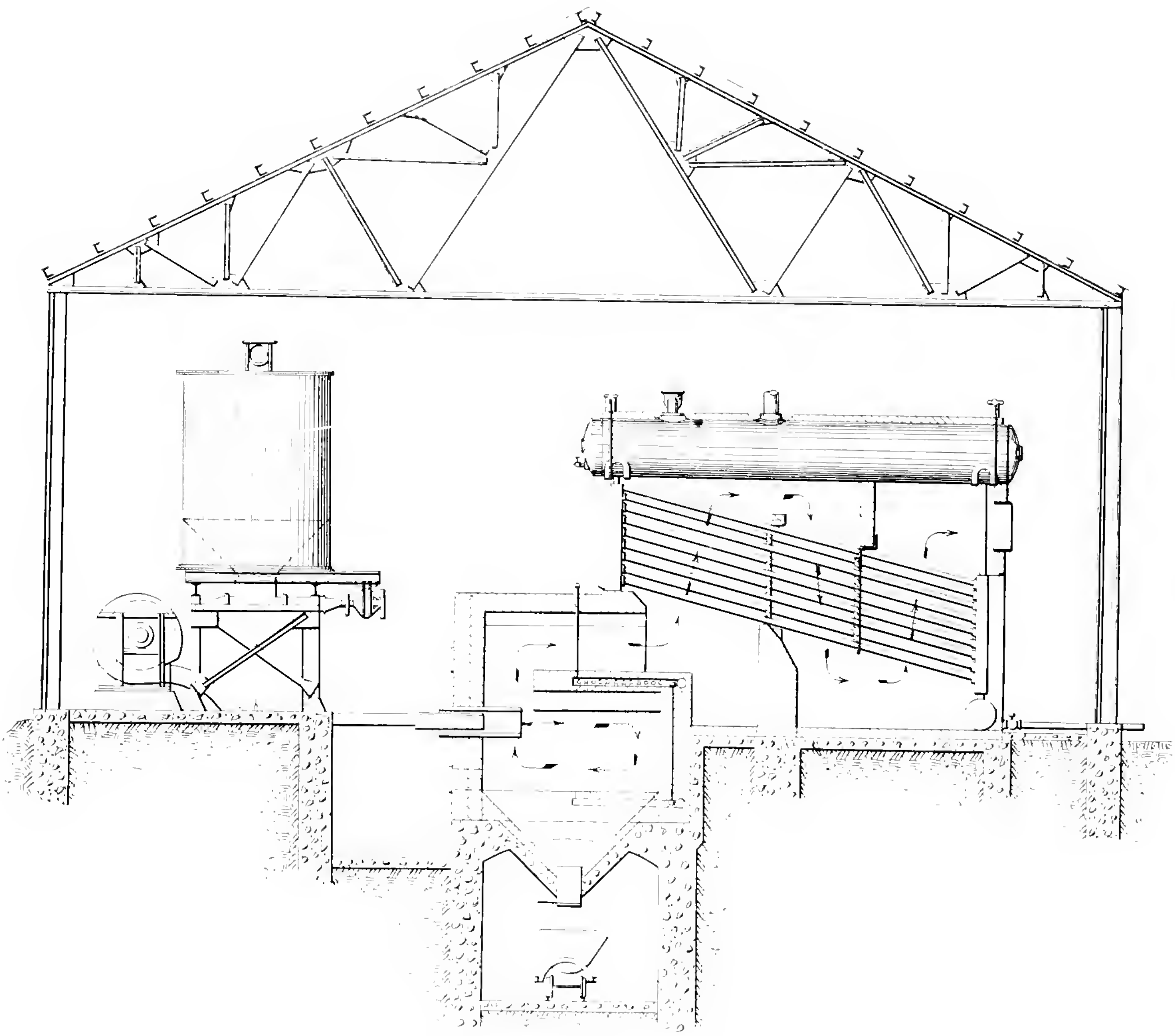


FIG. 3 DESIGN OF FURNACE FOR BURNING LOW-VOLATILE, HIGH FIXED-CARBON FUELS

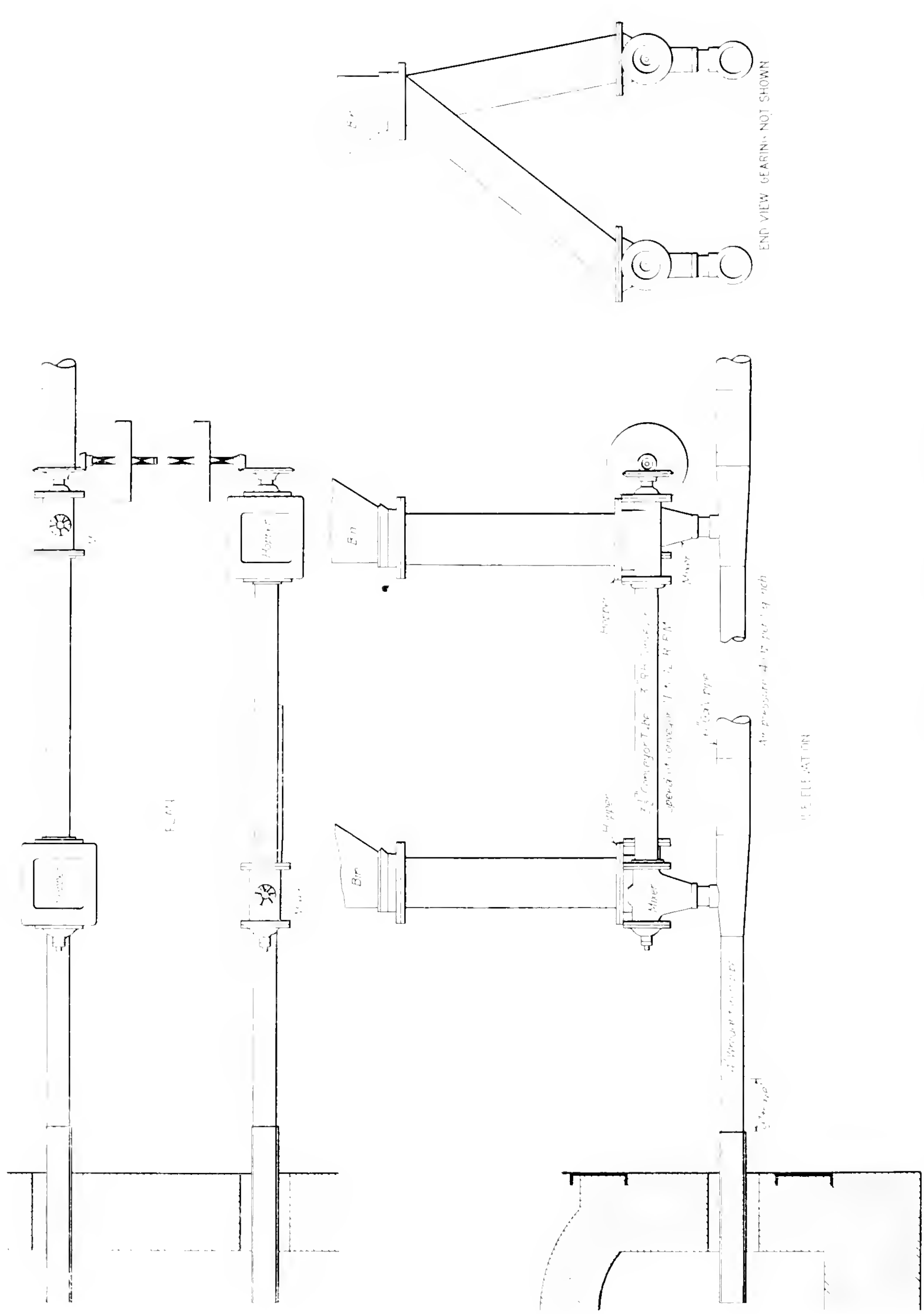


FIG. 1 DUNN SYSTEM FOR BURNING POWDERED FUEL

flame impinging upon the wall, causing a certain amount of the ash to settle and giving a proper distribution of heat on the hearth.—N. P. BARBA.

Fig. 3 shows a design of a furnace for burning low volatile, high fixed carbon fuels, such as anthracite, coke breeze, etc. In these furnaces the blast passes down and up and over an arch, thereby surrounding the incoming fuel and supplying the heat necessary for the initial ignition. The main principle governing the design of a furnace for burning pulverized coal is that it must be sufficiently large so that coal when burned will have time to complete its combustion before leaving the furnace. In open hearth furnace practice the same condition exists as in rotary kilns, i.e., the fuel must be projected and burned directly over the bath. Furnaces to suit fuel requirements for any individual operation should be designed especially for the work in question.—H. G. BARNHURST.

In puddle, heating, forge and like furnaces the high pressure air blast should range between 4 and 6 oz., the

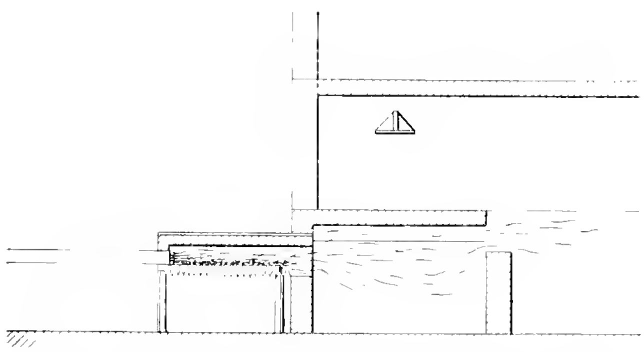


FIG 5 BRICK ARCH USED TO PROTECT THE FLAME FROM THE CHILLING EFFECT OF THE BOILER SURFACE

low pressure or volume air blast from 1 to 2 oz. In all experimental cases with air blast it is always advisable to begin with too low a pressure and slightly increase it until proper pressure is reached, rather than to begin with a high pressure and work down.—JOHN V. CULLINEY.

Fig. 4 shows a burner fitted to a reverberatory furnace. No change whatever was made in the furnace, which was formerly heated with oil. The burner tip is so constructed that it is readily adjustable. In starting the furnace, the burner tip is extended the full length and after ignition takes place it is gradually withdrawn so that it becomes flush with the inner wall.—W. R. DUNN.

(*Topics 10 and 12*) The essential features for furnaces for burning powdered fuel are emphasized in the almost complete failure to secure success under boilers. The essentials are temperature of at least 2000 deg. fahr. throughout the entire furnace and large combustion space, at least 1 cu. ft. for each 3 lb. of coal burned per hour. The boiler is essentially a low temperature furnace, seldom going over 1500 deg. fahr., and in no case does it offer sufficient space for combustion out of contact with the boiler surface. An idea of the space required under a water tube boiler running at modern high ratings is indicated in Fig. 4. This is almost prohibitive, at least for application to any existing plants. It would require a vertical height of 15 ft. below the tubes of a 600-h.p. boiler subject to peak loads of 1800 h.p. Horizontal return tubular boilers do not present the difficulty of space, for they are seldom run over rating, and are normally built with much larger combustion space throughout their entire length than is provided with any water tube boiler. They do, however, give difficulty from low tempera-

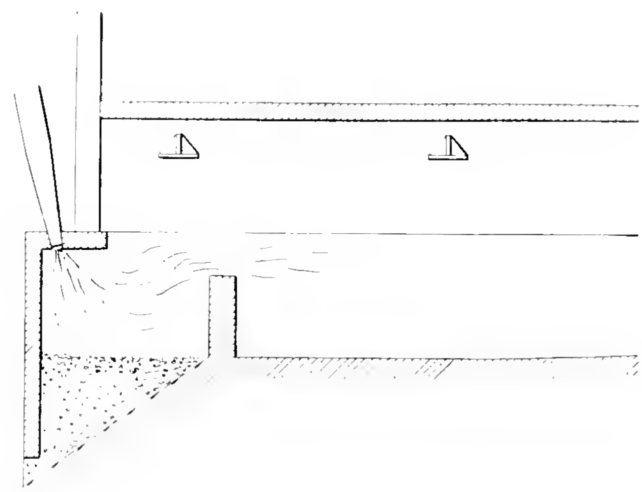


FIG 6 DESIGN OF FURNACE WITH BOTTOM SIDE SLANTING DOWN TOWARDS THE FRONT

ture. The writer has never been able to maintain combustion under a return tubular boiler except with the assistance of an auxiliary igniting flame, and after protecting the flame from the chilling effect of the boiler surface by a brick arch, run a considerable distance back, as shown in Fig. 5.

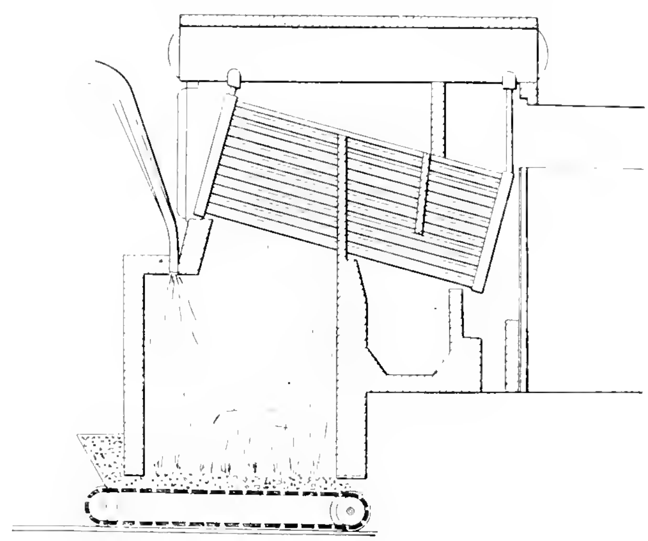


FIG. 7 DESIGN OF FURNACE WITH MOVING SIDE OR CHAIN GRATE

The auxiliary igniting flame was arranged as also shown in Fig. 5. It consisted of two 15-in. square steel boxes 5 ft. long, firebrick lined, leaving about 12 in. square inside, and with grate bars in the bottom. These were set directly in front of the two fire doors of the boiler. Coal fire carried on the grates provided the necessary igniting flame and was assisted by the close contact of the white-hot brick lining.

Aside from the difficulty of building combustion space large enough and of maintaining combustion, there is little

chance for powdered coal coming into general use on water tube boilers. The cost of grinding eats up any possible small advantage in economy it might have over the very efficient operation of mechanical stokers. The 95 to 97 per cent furnace efficiency of the latter leaves a very narrow margin for improvement; certainly not as much as 40 cents, the cost of grinding each ton of coal. That leaves the field for powdered fuel boiler firing possibly to horizontal return tubular boilers and to a few special conditions, such as waste fuel or a fuel that cannot be burned on stokers. The writer suggests a use that, to his knowledge, has not been tried. It is for peak loads. Powdered coal used only to supply the peak loads to heavily overloaded boilers would very much increase their capacity, would be in use only for short periods, would be entirely automatic, and might prove of untold values.

The writer's experience has been that wherever ash has a chance to deposit within the range of the flame slag will form and be of such a sticky, sluggish nature that it is next to impossible to remove it. It chills solid at 1800 deg., or as soon as any door is opened to break it out. It is suggested that a flux be used to make the slag more fluid, so as to allow it to be drawn off in its fluid state. The writer has never tried this.

A patent was recently issued to a Pittsburg concern involving the use of a furnace with its bottom side slanting down towards the front, as shown in Fig. 6. A narrow opening at the lower end is supposed to permit of drawing off ash at the same rate as it deposits on the top surface. This does, however, crust over on the top surface so that the slag does not settle down to the opening.

Another patent recently applied for involves the use of a moving side to a furnace such as a horizontal chain grate (Fig. 7), this grate to carry a bed of cinders or other protecting material, or even coal. Such a moving side or chain grate would continually remove the slag as fast as deposited, and the protecting material would form a very desirable indestructible impinging surface. This same arrangement with coal used on grate would permit of the coarser grinding of the powdered coal, allowing the coarse particles to drop to the grate, thus insuring complete combustion regardless of the coarser grinding.—W. A. Evans.

(11) *Air Pressure Used and Effect of Stack Draft on Combustion.*

Coal is blown into the furnace with air under 6 or 8 oz. pressure. This air supplies only a portion of the oxygen required for combustion, the balance being drawn into the furnace through openings around or near the burners. The amount of air drawn through these openings is dependent entirely on their area and the stack draft. The latter should be under control by means of a damper. The draft, at the throat of the furnace where the area is about 40 sq. ft., is usually between 1.0 and 1.2 in. of water.—J. L. Agnew.

The air for atomizing the powdered coal which we have used is under 4 to 6 oz. pressure, but we believe this to be higher than desirable. The air for combustion should be very low in volume. The stack apparently has little effect upon the combustion but is necessary to carry off ash and gases.—W. P. Barba.

In furnaces and in the pipes conveying the coal from the bins, there should be at all times a slight vacuum maintained so that leakage of any sort should be toward and not from the furnace. In other words stack draft should be sufficient to create a slight vacuum in furnace, and strong enough to take care of all the products of combustion.—H. G. Barnhurst.

It has been found advisable to place a damper on the top of the stack, keeping it almost closed during heating. With the damper in this position and the neck of the furnace as small as allowable, one obtains the best results with pulverized coal, both in the saving of coal and increase of furnace temperature and decrease of stack temperature.—John V. Culliney.

The air pressure generally used is 7 to 9 oz. per sq. in. The stack draft should be sufficient to carry off the products of combustion.—W. R. Dunn.

There is a great variance of opinion among the various users of powdered coal as to whether it should be fed into the furnace by air from an ordinary blower or by compressed air. There is no doubt that the use of a blast air increases the life of a furnace, as the flame does not seem to be quite so intense, and because of the lower velocity a more complete combustion is obtained in the combustion chamber. Those who uphold the use of compressed air say that it is necessary in order to obtain high temperatures.—A. W. Raymond.

(12) *Experiences with Ash or Slag in Furnace.*

The ash deposits largely in the combustion chamber, falling in front of the bridge wall as well as the hearth and tail of a continuous furnace. The slag is formed on the hearth which is removed by bars without a great deal of trouble. In the tail of the furnace the ash is soft and is usually pulled out with bent bars.—W. P. Barba.

The ash from the ordinary anthracite does not slag even though allowed to remain in the furnace for a considerable length of time. Soft coal ash, however, in most cases will settle down to the bottom of the furnace and if allowed to remain too long will slag. Most of the ash where pulverized coal is burned, passes out to the air above the chimney; what remains, if promptly removed, is easily cared for.—H. G. Barnhurst.

In regard to ash trouble, it might be said that only in furnaces operating at a temperature of 2000 deg. fahr. or less, is there any trouble of this kind. This difficulty is overcome by placing hoods over the door of the furnaces and connecting them to a suction fan which deposits the ash into a collector of the cyclone separator type.—John V. Culliney.

In the portland cement industry the formation of slag in the furnaces is unknown. The ash is generally collected in a dust chamber in the rear housing of the kiln.—W. R. Dunn.

(13) *What Temperatures are Maintained in Furnaces—Influence of Temperature on Formation of Slag.*

The working temperature of the furnace at its hottest part is about 2800 deg. fahr. This could be readily increased if desired, but the brickwork of the furnace would then suffer too severely. When working at the above temperature from 5 to 6 tons of material are smelted by 1 ton of coal. The kind of slag formed is determined by the nature

of the charge and should preferably run about 33 per cent to 35 per cent silica. Such a slag will flow from the furnace perfectly liquid at the prevailing temperature and also allow of a good separation from the matte.—J. L. Agnew.

Furnace temperatures can be controlled from 1800 to 3500 deg. fahr. If the air is preheated, there is no doubt but that considerably lower temperatures can be readily controlled, provided the temperature of furnace is above the kindling temperatures of the fuel. Slag is formed more easily with high temperatures than with low. Hence with thorough control of the burning mixture, serious results can be avoided. —H. G. Barnhurst.

The highest temperature in a rotary cement kiln is approximately 2600 deg. fahr. Temperatures high enough to melt nickel readily have been obtained with pulverized coal in reverberatory furnaces.—W. R. Dunn.

(14) *Experience with Checkerwork in Metallurgical Furnaces.*

None is used here, but the waste heat is utilized for generating steam in a boiler set in the flue. It is estimated that about 500 h.p. could be obtained in this way from the waste heat of one furnace when burning about 70 tons per day.—J. L. Agnew.

In regard to this item the only furnaces which we have had experience with, where checkerwork would enter into the construction, are those in connection with open-hearth furnaces, and it has been found that no serious trouble arose with the checkerwork or baffle walls. Checkerwork should be so designed that there is no horizontal or level places on which the ash could settle. We have not heard of any serious complaints with checkerwork—in fact, we know of one open-hearth furnace where 152 consecutive heats were obtained before furnace brick work necessitated shutting down for repairs, and there was no serious closing up of the checkerwork. The furnace brick work gave out before the checkerwork was choked up in any way.—H. G. Barnhurst.

In small singeing furnaces, a system of checkerwork acted as a bar to complete combustion and resulted in the formation of a considerable quantity of coke.—W. R. Dunn.

(15) *Life of Furnace as Compared with Furnaces using Other Fuels.*

The life of a reverberatory furnace is not adversely affected by the use of pulverized coal. As a matter of fact it is probably prolonged. On account of the uniformity of the heat, the contractions and expansions, which are unavoidable when grate firing is used, are done away with completely and consequently the furnace is much more likely to have a long life.—J. L. Agnew.

It is our opinion, without definite data to substantiate it, that the life of a furnace running with powdered coal is greater than that of a furnace using oil. We may safely say at least that the use of powdered coal does not appear noticeably to injure the furnace.—W. P. Barba.

The life of furnaces using pulverized coal naturally depends upon the type of furnace. Rotary kilns using pulverized coal, where the heat is being carried out with the outgoing clinker and is not cumulative in its effect, have linings which last from 8 months to 16 months; the lining, however, is subject to erosion by raw materials and clinker. The life of furnaces using pulverized coal is equal to that of hand-fired or oil-fired furnaces. With proper furnace control and using pulverized coal properly prepared the brick work should last just as long as when using any other kind of fuel.—H. G. Barnhurst.

The life of the furnace is about the same as the life of a furnace using fuel oil. I have known of cases where rotary kilns in the portland cement industry have retained their original lining for a period exceeding 26 months.—W. R. Dunn.

Pulverized coal furnaces operated at low air pressures will last longer than the ordinary hand-fired furnaces. By using too high air-pressure the bridge wall and roof of the furnace are destroyed and also the furnace waste is increased.—John V. Culliney.

(16) *Items of Expense or Economy in the Plant as a Whole, due to Use of Powdered Fuel.*

The main item of expense in the use of pulverized coal is the installation of the necessary plant for grinding the coal and distributing the dust to the points where it is to be burned. Next to this would come the power required and the repairs.

To offset these items of expense the labor required is less with dust firing than with the usual method. The latter would require at least double the number of men and the work would be of a much more trying kind. There would also be a considerable amount of ash and clinker to dispose of each day and an unavoidable loss of partly burned coal would occur in this material.

The great advantage, however, of pulverized coal firing is in the efficiency. The heat is uniform and under perfect control, the combustion is complete and takes place where it will do most good, but above all there is no delay for grating with an accompanying drop in temperature. The furnace is always working, and working at a uniform rate, both of which points are essential to efficiency.—J. L. Agnew.

Under the maximum production in a powdered coal installation it is probable that a good economy can be obtained. In our own case, on account of slackness in manufacture for which the powdered coal plant was installed, we have been unable to run economically or get any data on what we may expect under the best conditions.—W. P. Barba.

The economy of an installation for preparing pulverized coal as a fuel naturally depends upon the price of other fuels obtainable. The economy, however, obtained in the use of pulverized coal as against hand-fired furnaces in certain types of furnaces is remarkable.

In furnaces for heating billets, from 20 to 25 per cent has been saved; in open-hearth furnaces in comparison with producers, from 30 to 40 per cent; in puddling furnaces, from 33 to 50 per cent; in heating and bushelling furnaces, 20 to 25 per cent. These figures are authentic and can be verified. The principal items of expense are naturally the cost of preparing pulverized coal. The advisability of making a pulverized coal installation naturally depends on whether the saving obtained by increased efficiency of burning will overcome the additional cost of preparing the fuel. —H. G. Barnhurst.

The saving by the use of pulverized coal is made up largely of (*a*) practically perfect combustion, (*b*) no handling of coal or ash (*c*) no poking or clinkering, and (*d*) constant and uniform heat, resembling a gas fire and as easily controlled.

One other item which might be mentioned is the use of preheated air. By passing preheated air into a furnace at, say 600 deg. fahr., the number of B.t.u. required to heat this air, in the combustion chamber, from room temperature to 600 deg. fahr. is saved. The saving is not made up of this item alone but also by the increase of furnace efficiency. That is (*a*) more heats per hour, (*b*) higher furnace temperature, (*c*) uniform temperature, (*d*) less ash deposited on hearth of furnace.

In furnaces having waste heat horizontal boilers above them, wrought-iron pipes are placed in the boiler setting underneath the boiler. This robs the boiler of very little heat and at the same time causes a saving of about 15 per cent in the amount of coal used.

In small furnaces the pre-heated pipes are placed underneath hearth.

The American Iron & Steel Manufacturing Company have forging furnaces operated daily for the last nine years on pulverized coal. These furnaces range in size from 20 in. by 36 in. to 7 ft. by 16 ft., and are used for heating bolt, nut, spike and rivet bars and also for puddling, bushelling and heating. Drop forge for both small and large hammers.

Operating under normal conditions, we use about 260 tons (gross) of pulverized coal per day.—JOHN V. CULLINEY.

The chief item of economy in the use of powdered coal is the enormous saving effected as compared to the use of fuel oil. Another item of economy is the saving, due to a large elimination of labor expense.

Another great saving is effected, due to the perfect combustion of the coal. There are no unburned clinkers—the chief item of expense is the cost for power in grinding the coal.—W. R. DUNN.

DISCUSSION

A. G. CHRISTIE: Referring to the boiler shown in Fig. 8, I was in England about four years ago and had the pleasure of seeing one of the first units of this type in operation. During a visit there last year I went out again to see the same plant, and they reported quite favorably on the installation. It was the works of the makers themselves, where the boiler had been in practically continuous service under ordinary operating conditions in connection with their plant, supplying steam to the engines of their plant and also for their test floor.

While at the plant I asked the fireman to shovel out some of the ash which was dripping down into the ash pit and I brought some of it away as an exhibit to those here who would be interested in that boiler. The ash comes down as a slag from the brick and is shoveled out in the form of small drippings from the lining of the furnace. It does not seem to form any solid mass, and is easily broken up with a shovel. The operators reported very favorably in regard to operation and economy. It required very little care to keep the plant in operation and very little attendance from the fireman.

These boilers are used quite largely in South Africa, where they have a coal which dusts badly after it is mined. Many of the coals in the Canadian West have the same characteristics. They are not coking coals and disintegrate as soon as they are exposed to the air, due largely to the heavy rock pressure to which they have been subjected. It may be that this boiler will be applicable to that type of coal, i.e., one which does not coke and which powders badly on exposure to air.

GEORGE E. PFISTERER: I have had some experience in the use of oil to take care of peak loads for central station work. Peak loads are, as is well known, not like normal loads, and it is often very hard to handle them, particularly when a certain equipment is more or less limited in capacity. A peak load is the source of high maintenance cost because of the extra boiler equipment necessary, and also high operating cost because of the banked fires which have to be maintained. It is easily the hardest part of your boiler room work to handle, and it might be possible, under certain conditions, that pulverized fuel will be able to take care of these peak loads without extra boiler equipment, or without loss of coal due to banking.

The use of powdered coal is, I believe, more or less an experiment; there have been only about ten or twelve cases in which pulverized coal experiments have been tried out, and in most all of these cases, the relative efficiency, as compared to the best modern boiler practice, has only been increased 10 per cent gross, or a net increase of 15 per cent. The other points, however, in regard to maintenance, adaptability and convenience of powdered fuel, do not recommend it for every condition, and consequently stokers will probably maintain the place they have always held. For peak loads, it might be possible to utilize powdered fuel to tide over for a couple of hours, and the extra cost of equipment might be low as compared to the reduced fuel cost that might result while taking care of these peak loads. If we could get a stoker which would run continuously for 24 hours at a uniform rate, and would not have to be handled or disturbed, we could increase the efficiency to a considerable extent, probably 3 or 4 per cent, and if we could use pulverized fuel to tide us over peak loads, it might be possible to reduce the coal cost per kw. hour very considerably.

Powdered fuel in connection with locomotives has been practically untried. I know of one case where it was tried, but was very soon abandoned, the results obtained being not worthy of any further expenditure of money. The greatest trouble was that the grates would become clogged in a very short space of time, so that the feeding of coal had to be discontinued, and the steam pressure would consequently drop.

L. E. OSBORNE: As a large number of the members attending the Spring Meeting observed the working of the Street locomotive stoker on Burlington locomotive No. 6001 at Grand Crossing, Wis., I wish to suggest that with this stoker firing coal containing a considerable percentage of fine coal and coal dust, we have a condition to some extent similar to the burning of powdered fuel. As was seen, this machine blows the coal over the grate area with three jets. The very finest coal is burned in suspension and does not reach the grates. This stoker can successfully fire coals containing a large percentage of very fine coal and which cannot be successfully fired with the shovel.

CHAS. WHITING BAKER: This discussion on burning powdered coal throws light on the question, once much discussed in technical literature, as to whether the presence of water vapor in a boiler furnace, such as is furnished, for instance, by a steam jet blower, adds to or detracts from the efficiency of the furnace. The weight of scientific opinion has always been that the admission of water to the furnace, whether as moisture in the coal as steam from a blower, or otherwise, is detrimental to efficiency. It has been claimed, however, that where the water was admitted in such a way as to be decomposed to form water gas, which was later burned to CO_2, a more complete combustion of the coal was attained and there was less loss due to incomplete combustion.

The universal testimony in these papers and discussions, however, is that with powdered coal the moisture in the coal must be reduced to the lowest point to facilitate the distribution of the dust by the blast, and further, that this dried coal burns perfectly to CO_2, notwithstanding the absence of moisture.

LOREN L. HEBEERD (written): It has been brought out in the paper on Pulverized Coal for Steam Making, that the most important features or difficulties encountered are the disposal of incombustibles and the maintenance of the furnace. When these troubles are sidestepped by the use of excess air other serious faults are introduced; first, the incombustible in the form of dust is either deposited through the boiler passes or is carried out the stack; second, the efficiency and capacity suffers to such an extent that the system may become an economic failure.

It would therefore seem that the trend of experimentation should be to develop a furnace and a refractory material to withstand the heat. Under such conditions the ash would be slagged and the design must necessarily provide for its frequent removal. When these conditions are satisfied then high capacity and efficiency will necessarily follow. No doubt past investigators have satisfied themselves that this is impossible, but that does not prove that it will not be accomplished.

Of the various types of apparatus described in this paper it would appear that the Bettington boiler is a big step in the right direction and will lead eventually to successful results.

J. G. COUTANT: The American Iron & Steel Mfg. Co. have a dust collecting system installed in connection with all small furnaces, which embraces hoods over all furnaces so arranged as to collect all dust and gases issuing from the front of the furnaces over the work. The hoods are all connected with a heavy galvanized iron pipe through which the gases and dust are exhausted by a steel plate fan which discharges into a cyclone type dust collector. The gases suddenly admitted into the enlarged area lose most of their velocity and escape through an opening in the top to a stack; while the heavier dust and ash matter falls through the discharge orifice into a bin. With this system gases of 500 deg. to 600 deg. Fahr. are handled at 3 oz. vacuum and about 500 lb. of ash collected daily.

CHAS. J. DAVIDSON: It has occurred to me that in attempting to make the use of powdered fuel general, particularly in boiler furnaces, there is a serious obstacle, which apparently has not received serious consideration. I refer to the ash in finely divided particles, which is carried up the stack with the products combustion, and thereafter falls on the roofs or surrounding buildings and other objects which are exposed, and in the streets. In cement mills, lime kilns, etc., this probably is not a serious consideration. But, should an attempt be made to use this form of fuel in cities, while there might be no visible smoke, the residue referred to is, generally speaking, much more objectionable than smoke so-called, and might become a great nuisance and be legally prohibited. I would appreciate it very much if those who have had experience along this line would elucidate their ideas relative to this detail of the subject.

NECROLOGY

CHARLES HAZELTINE BASSHOR

Charles Hazeltine Basshor was born in Baltimore, Md., May 30, 1871, and died at his home near Cambridge, Md., August 22, 1914. He was educated at private schools in Baltimore. His shop experience and apprenticeship was served under his father, Thomas C. Basshor. Upon his father's death he succeeded him as head of the Thomas C. Basshor Company of Baltimore, and continued the business until about two years ago, when he retired.

Mr. Basshor was a member of the Engineers' Club of New York, the Maryland Club, the Kennels, the Green Spring Hunt Club, the Baltimore Country Club, and the Cambridge Yacht Club.

QUIMBY N. EVANS

Quimby N. Evans was born August 15, 1845, at Lovell, Me., and had a common school education at Freyburg, Mass. He served an apprenticeship with the Pitkin Brothers, steamfitters, at Hartford, Conn., and later entered the Walworth Manufacturing Company and then the Walker & Pratt Company, in Boston, Mass. He left the latter company to become chief engineer at the Boylston Hotel.

In 1880 Mr. Evans formed a partnership with Frederick Tudor, under the name of Tudor & Company, and engaged in the steamfitting business, and in 1881 entered into a partnership with Mr. Joslyn, as Q. N. Evans & Company of Boston and New York. Several years later Mr. Evans entered the Otis Elevator Company of New York as superintendent of construction, but in 1885 he again returned to the steamfitting business, forming the corporation known as the Q. N. Evans Construction Company. This concern was maintained under that name until 1895 when the present firm of Evans, Almirall & Company was formed.

During his early connection with the Q. N. Evans Construction Company, they designed and installed the heating and ventilating systems in the Leake and Watts Orphan Asylum of New York, the Criminal Court House of New York, and the English and Latin School, and also the heating and ventilating plant in the original capitol building in Albany, N. Y. He died on July 7, 1914.

Mr. Evans was a member of the Montauk Club of Brooklyn, N. Y.

JOHN DOWNING LOGAN

John D. Logan died at his home in Hillsdale, N. Y., on March 15, 1914. Mr. Logan was born on January 14, 1863,

in Brooklyn, N. Y., and was educated in the public schools of Brooklyn. For a time he attended the Polytechnic Institute of that city and was graduated from Columbia College in 1884. He served his apprenticeship with John Roach & Sons, shipbuilders, at Chester, Pa., and in 1885 entered the Logan Iron Works in Brooklyn, of which he was for many years secretary and superintendent.

Mr. Logan was regarded as one of the most shrewd and intelligent of engineers, and was frequently sought out to solve some very difficult problem. He made many improvements in steel working machines, which, however, he never patented. He was responsible for the simplification and improving of the shields used in the tunnels on both the North and East Rivers.

Mr. Logan was also secretary of the Logan Real Estate Company, and was a member of the Illuminating Engineers Society.

WILLIAM BLEECKER POTTER

William Bleecker Potter, founder and manager of the St. Louis Sampling & Testing Works and one of the best known mining engineers and metallurgists in the United States, died at his home in St. Louis on July 14, 1914.

Mr. Potter was born in Schenectady, N. Y., March 23, 1846, and received his A.B. degree at Columbia in 1866, his A.M. in 1869, and his E.M. in the School of Mines, Columbia, in 1869. After his graduation he studied for a time in Germany. He acted as assistant in geology at Columbia from 1869 to 1871, and was an assistant in geological survey in Ohio.

In 1871 he was appointed professor of mining and metallurgy in Washington University, the year in which this chair was founded, and remained at the head of the department, which had a phenomenal growth, until 1893. The department was abandoned after his resignation.

He founded the St. Louis Sampling & Testing Works in 1886 as a metallurgical and chemical laboratory for the benefit of the students of Washington University.

In 1889 he was placed on the board of the Missouri Geological Survey and served until 1893. He was an assistant in geological survey in Missouri from 1872 to 1874, engineer of the Pilot Knob Iron Company, 1874 to 1878, metallurgist for the Vulcan Iron and Steel Works, 1876 to 1878, and chief engineer of the Iron Mountain Mining Company from 1882 to 1893.

Mr. Potter was widely known both as a practising and consulting engineer. He was a past-president of the American Institute of Mining Engineers and of the St. Louis Engineers' Club, and a member of the Mining and Metallurgical Society of America, and a corresponding member of the New York Academy of Science, Wisconsin Academy of Science and National Geographic Society.

He received the honorary degree of Sc.D. from Columbia University in 1904 in recognition of his services in the field of mining and metallurgy.

SIDNEY LEROY SMITH

Sidney Leroy Smith, who was born in Boston, Mass., March 29, 1838, died in the same city on May 25, 1914. He was graduated from Dartmouth College with the B.S. degree, and his first position was as resident engineer in charge of the construction of a railroad between Sheboygan and Fond du Lac, Wis. In 1861 he entered the engineer corps of the United States Navy, continuing in the service after the close of the war. At the time of his resignation in 1884 he was acting as assistant engineer. From 1894 to 1897 Mr. Smith was superintendent of the Roxbury Carpet Company, Boston, Mass.

Mr. Smith was a member of the American Society of Naval Engineers and of the Loyal Legion.

ALFRED P. TRAUTWEIN

Alfred P. Trautwein, vice-president of the American Welding Company, Carbondale, Pa., died at his home in that city on August 5, 1914. He was born in New York City on October 10, 1857, and was graduated from Stevens Institute of Technology in 1876. In the same year he entered the employ of the Continental Iron Works, Brooklyn, as mechanical draftsman and engineer, engaged in the construction of coal and water gas works, fuel gas plants, ice making and refrigerating machinery and marine construction. In 1889 he removed to Carbondale and entered the Hendrick Manufacturing Company as superintendent and consulting engineer. Ten years later he organized the Carbondale Machine Company and was president for a number of years. He also organized the Carbondale Supply Company, the Carbondale Chemical Company, now known as the Carbondale Calcium Company, the American Welding Company, and the Carbondale Instrument Company. He was also one of the reorganizers of the Consolidated Telephone Company and until recently was one of its directors. At one time he acted as president of the American Acid and Alkali Company of Bradford, Pa., and was a former director of the Buffalo Cold Storage Company, Buffalo, N. Y. Mr. Trautwein was also one of the organizers and until a short time ago one of the directors of the Pioneer Dime Bank. During the past three years he had devoted the greater part of his time to the Barium Products Company of Scranton, Pa., of which he was president. He was a director in the Carbondale Machine Company and the American Welding Company at the time of his death.

Mr. Trautwein first pointed out the advantages of the anthracite coal region for the silk industry, and it was through his persistent efforts that the chain of Klots Mills was located in the region of Carbondale. This was followed in turn by the Empire Silk Company, and Mr. Trautwein was himself one of the organizers of the Carbondale Knitting Company. He did much throughout the valley to develop its industrial interests, and while he never took an active part in politics he was always ready and willing to lend financial and moral support to every movement instituted for the welfare of the community.

He served Stevens Institute in the capacity of alumni trustee from 1887 to 1890, and was a member of the Engineers Club of New York, the Manufacturers Club of Scranton, the Engineers Club of Scranton, and the Drug Trade Club of New York.

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

EFFECT OF THE WAR ON FOREIGN PERIODICALS

The war in Europe has wrought sad havoc with the files of foreign periodicals in the Library of the Engineering Societies. The English, Italian and Scandinavian periodicals come in with fair regularity, and with practically their usual number of pages. The German periodicals have been either discontinued (as the Werkstattstechnik announced, because "nobody cares to read trade papers now"), or are issued in reduced sizes, and delivered with great irregularity. The Belgian papers, published at Louvain and Brussels, have been discontinued for obvious reasons. The French papers have been so far coming in regularly, but sometimes in reduced sizes. No Russian papers have come in since the beginning of the war, although regularly issued. No Austrian papers have been received, and no information as to their being issued is available. Notwithstanding all these circumstances, enough material is available to carry on the work of the Engineering Survey in the usual manner.

THE VALUE OF THE ENGINEERING SURVEY TO STUDENTS

Now that a new school year begins, it may be in order to call to the attention of future engineers in our colleges the benefits which they may derive from getting into the habit of looking over every month the Engineering Survey in *The Journal*. During their freshman and sophomore years they will probably find a good deal that will be somewhat beyond their depth, but even then a number of articles will be such that they can readily understand. A junior in either mechanical or electrical engineering ought to be able to understand the gist of nearly every article. What a student can learn from a perusal of the Engineering Survey month after month is, first, the general tendencies of modern invention both in Europe and in this country; second, the point of view taken by prominent designers here and abroad in the selection of their engineering equipment; and finally he will learn the names of the periodicals and publications of societies where information on various subjects may be found. When it comes to writing his thesis, and especially when after graduating from college he happens to run across some work of design along individual lines, he will find the ability to look with some certainty for information in the more or less out of the way periodicals—an advantage of inestimable value. There are good engineers in countries and localities of which the ordinary engineer thinks very little: in China, Australia, South Africa, Chile. These engineers run across peculiar problems and often solve in special ways, the knowledge of which may be of the greatest possible value to the American engineer when *he* gets into a similar tight place. The Engineering Survey, within the space available, is doing its best to present all such information in as clear and readable a manner as possible, and the engineering student, who makes a habit of reading it over as it comes out, will soon find that a lot of the information which he gets from it, sticks, and can be used even in his work at college.

THIS MONTH'S ARTICLES

In the section Aeronautics is given an abstract of a paper by Professor Ch. Maurain on the progress of experimental work in aeronautical engineering, especially interesting at the present time when the events in Europe have directed serious attention to aircraft as a means of national defense. The abstract, among other things, contains a list of European aeronautical laboratories.

The next article gives data on endurance tests of heavy automobile trucks. The section on Internal Combustion Engineering goes into considerable detail concerning the use of explosion engines in railway work, such as branch lines and for light trains on secondary lines. Particular attention is paid to the problem of power recuperation during the downgrade runs or slowing up of trains. In the section Steam Engineering are described a German triple-flue boiler plant and a new evaporation apparatus for the production of distilled water in which a part of the steam of evaporation is compressed by live steam and takes further part in the process of evaporation.

Two papers before the American Foundrymen's Association are devoted to the discussion of the influence of the skin on the strength and ductility of malleable cast iron (Touceda), and to the elimination of waste motion in bench molding (Kennedy and Pendleton). In the former paper data of tests on the strength of machined and unmachined test wedges of malleable cast iron are reported, and certain ideas on the importance of the skin are combated. From the Bulletin of the American Institute of Mining Engineers are abstracted several interesting papers: on nodulizing flue dust which may be of interest to those engineers who have to work with blast furnace gases for heat engines and boiler firing; on the annealing of cold rolled copper; and on surface decarbonization of tool steel. The last paper contains an interesting explanation as to why the "bark" on tool steel is so hard on machining tools.

Marshall R. Pugh, before the American Society of Civil Engineers, presented a comprehensive discussion of external corrosion of cast iron pipe, a subject which has been of late attracting considerable attention both in this country and abroad. From the Journal of the American Society of Naval Engineers is taken an abstract of the account of the work of the U. S. Navy Engineering Experiment Station, containing among other things data on the compound issued to the service for rendering boiler materials non-corrosive.

From the Transactions of the Canadian Society of Civil Engineers are taken data on concrete stack construction and on disregarded stresses in joints and ends of steel in reinforced concrete construction.

An interesting consideration of pitot tube formulae, and data of tests of pitot tubes and two different types of current meters, as applied to the measurement of large volumes of water flowing at variable velocities, are presented in the abstract of a paper of B. F. Groat before the Engineers' Society of Western Pennsylvania, and an equally interesting paper (by Gerald Stoney) on high speed bearings, and several subjects closely associated with this subject, such as oil-

cooling, is reported from the Transactions of the North-East Coast Institution of Engineers and Shipbuilders.

FOREIGN REVIEW

Aeronautics

Review of Experimental Work in Aeronautical Engineering (*Revue d'aérotechnique expérimentale*, Professor Ch. Maurain. *Revue générale des sciences*, vol. 25, no. 14, p. 679, July 30, 1914, 8 pp., *tg*). The present article gives a review of the work lately done in the great aeronautical laboratories of Europe and America. In France the military laboratories continue the splendid work started years ago by Colonel Renard. In addition to that, there are several extremely well-equipped civilian laboratories, such as the well-known laboratory of Mr. Eiffel, the laboratory of the Duke of Guiche, who uses the special method for recording photographically pressures and partial depressions existing at the same instant at different points of surfaces or other parts carried on specially equipped automobiles. The Aeronautical Institute of the University of Paris, founded by Deutsch de la Meurthe, uses several methods simultaneously, such as the dynamometric car, rotating arm, air tunnel and measurements in actual flights. In Russia, the laboratory of Koochino, started by a private scientist, Mr. Ribooshinsky, has for many years carried on various experiments on surfaces and propellers by means of an air tunnel. Other aerodynamic investigations are being carried on in the laboratories of several of the technical schools; those of the University of Moscow, under the direction of Professor Joukowsky, deserve special mention. In Germany, the laboratory of the University of Göttingen, under the direction of Professor Prandtl, has been for several years using the method of air tunnel and rendered valuable service to the art of aviation. Another well-equipped laboratory has recently been installed at Aldershof (under the direction of F. Bendemann, of the German Institution for Experimentation in Aviation), the chief purpose of which is the test of motor propeller sets, although a wider field of experimentation is under contemplation for the future. Valuable measurements on propeller action have been made at Frankfort by means of the dynamometric car. In addition to that there is the aerodynamic laboratory of the Berlin technical high school, under the direction of Major von Parseval, while in Austria, an aerodynamic laboratory has been installed in connection with the technical high school of Vienna, under the direction of W. von Doblhoff. In Italy the military laboratory of aerodynamics at Rome is under the direction of Crocco, and has published several important researches on aerodynamics and hydrodynamics. All aerodynamic experiments are made by the method of air tunnel, while the hydrodynamic experiments are made in an experimental tank, with a towing car. In England a special committee has been appointed for research in connection with aeronautics under the chairmanship of Lord Rayleigh, the actual work being done at the National Physical Laboratory at Teddington by the method of air tunnel and, for propellers, by rotating arm. This work is carried on in such a manner as to collaborate with either civil or military laboratories, in particular that of the Royal Aircraft Manufacture.

The work of these laboratories is not always systematic, which is due mainly to the fact that the extremely rapid development of aviation made it necessary to find immediate answers to practical questions instead of taking up more general questions of scientific interest. The degree of precision of the various methods of measurements has not yet been fully established, and each laboratory being equipped preferably for a certain kind of measurements, is doing the work which it is best able to do, without often attaching too much value to the absolute worth of the results obtained. It will require long and delicate comparisons between the results obtained by the various methods to establish answers to the most important general problems.

The author proceeds to describe in a general manner experimental investigations having for their purpose the determination of the general laws of flight, such as, for example, the supporting action of air as a function of the relative velocity of the plane and density of air, and the investigations made to determine the value of the coefficient K used in this formula. A large amount of investigation has been devoted to the study of the numerical relations in the action of air on aeroplanes, so as to determine the velocity and position of such action for various inclinations of the planes as functions of the relative velocities, and for various positions of the vertical rudder with respect to the main planes. The data collected already enable us to solve a number of important problems, e.g., to calculate the conditions of equilibrium of an aeroplane, to construct a metacentric curve and to deduce the conditions of stability. These investigations have had an especially important bearing on the study of stability of aeroplanes. G. de Bothézat has shown by the method of small motions applied to an aeroplane in still air, that if the aeroplane be assumed to be non-deformable, it will be stable longitudinally, but that it will remain inherently unstable laterally. By stability is meant the ability of the aeroplane to resume its normal position after having been, by whatever cause, slightly brought out of it. While these results are of considerable theoretical interest, it must be remembered that in practice the important point is to secure stability not in still air but in gusts. In practice also, aeroplanes are not non-deformable systems. The pilot intervenes all the time with a view of reestablishing, by means of his rudders or ailerons, the equilibrium disturbed by the movements in the atmosphere, and the conditions which must particularly be realized in the design of a machine consist in proportioning the efficiency of the means of governing to the amplitude which the violent disturbances of the atmosphere may produce in the action of the planes, so as to permit the pilot at all times to remain master of his apparatus. The methods of computation based on the general principle of small motions do not indicate what may happen during violent atmospheric disturbances, and it is here that the great value of the excellent methods of registering the relative velocity of the aeroplane, its inclination, inclination of its trajectory, movements of the governing devices, etc., introduced by Toussaint, and Lepère and Gouin, come into play. It is significant that the school of aviators, represented by men like Blériot, believe that the security in aviation can be realized by making aeroplanes extremely easy to manage, so that the pilot may without difficulty execute the most complicated movements without losing control of his machine. When he happens, therefore, to meet violent atmospheric disturbances, these disturbances produce variations of flight, but only such as he has been in the habit of creating himself. This is correct, with the restriction, however, that it requires a flight at a considerable elevation,

since nearly all evolutions in the aeroplane involve loss of height, as flights near the ground during a strong and irregular wind appear to be especially dangerous to a light machine.

The second part of the article reviews the experimental work done on aerial propellers. From a practical point of view, it is important to note that it is possible to determine now the characteristics of propellers working not only as fans but while in motion at a certain speed. Aerial propellers have already reached maximum efficiencies of from 70 to 80 per cent and sometimes have exceeded this value. The author believes that with the present-day propellers and explosion motors, helicopters have already become possible, but will have no practical application until some method has been found to prevent the fall of the machine if the engine becomes stalled. It is, however, possible that the combination of helicopters and aeroplanes may bring about the realization of the dream of large aerial vessels easily governed and perfectly stable.

Automobiles

Military Endurance Tests of Automobile Trucks (*L'épreuve militaire d'endurance des automobiles de poids lourds, du 1er au 30 juillet 1914*, Duroc, *Le Génie Civil*, vol. 55, no. 15, p. 289, August 8, 1914, 5 pp., 16 figs., *de*). The article gives some data on the practical endurance tests of heavy motor trucks carried out in France during July 1914. The original program of the tests contemplated runs from July 1 to August 4 of 100 km. every day for tractors and 150 km. per day for motor trucks, with a final examination to be made between August 5 and August 8. The declaration of war compelled the commission, on July 30, to release all the trucks from the test and to pronounce 60 out of the 66 trucks as having satisfied all conditions.

There were, in the performance of these tests, certain particulars worthy of notice. For example, contrary to the method of performing the tests adopted in 1913, all the runs this time were made along roads converging, star fashion, to the city of Versailles, so that every day the cars started from that city and returned to it at night. While in this way the demonstration of the motor trucks under test in various provincial cities, with its corresponding advertising advantages, has been omitted, there is no doubt but that the cost of the test to the manufacturers has been very materially reduced and the observations by the authorities were, to an equal degree, simplified.

The military commission and the war office have made the following regulations for the present tests:

The gross weight of the truck of 3500 kg. does not include tools, spare parts and driver, the rear axle thus being permitted to carry a load up to 5000 kg. The engine must be placed under wood, which is reasonable, because it makes it more accessible and easier to inspect.

Sixty-six trucks have actually entered the competition. The engines of all the four-cylinder vertical type have a volume swept over by the piston of 4.500 liters which corresponds at a speed of 1200 r.p.m. to an average h.p. on the testing stand of 28.30 h.p.

Internal-Combustion Engineering

Traction by Thermal Engines on Railways (*La traction par moteurs thermiques sur voies ferrées*, L. Saint-Martin, *Bulletin mensuel de la Société Belge des Electriciens*, vol. 31, p. 485, July 1914, 80 pp., 8 figs., *dge*). The article presents an extensive discussion of the various forms of motive power for railroads, such as steam locomotives, electric locomotives and internal combustion locomotives. In connection with the latter, the author discusses in considerable detail the internal combustion locomotive with an auxiliary electric drive such as is represented by the H. Pieper system (compare *The Journal*, March 1913, p. 532). It is a well-known fact that the maximum power developed by an internal-combustion engine approaches very closely the most economical power at which it can be operated so that an internal-combustion locomotive set does not easily adapt itself to taking up overloads. The Pieper system provides for such emergencies by combining with the internal-combustion engine an electric unit which may be used either as a generator or as a motor, and a set of storage batteries. When the entire power of the engine is not utilized for purposes of direct propulsion, the reserve is taken up by the dynamo which then acts as a generator and charges the storage batteries. On the other hand, when an overload is brought on the engine, the batteries discharge through the dynamo, which acts as a motor and boosts the engine action. This is what the author calls a "buffer" system.

One of the interesting parts of this type of drive is the fact that it appears to present an elegant solution of the problem of power recuperation. There have been a good many systems proposed for recuperation of power loss during the down-grade runs and in slowing-up, but the numerous devices so far proposed have proved to be failures. It is only in storage battery cars, e.g., on the tramway line from Paris to Saint Denis, that as much as 10 to 14 per cent of the total power has been recuperated. This, however, is of little practical importance on account of the limited use of the storage battery cars.

Numerous tests have also been made on mountain electric railway lines where an effort was made to drive the motor as a generator during the down-grade run and return the current thus generated to the central station. In order, however, that this might be possible, the generator has to deliver current at a higher voltage than the one existing at the line contact, and when a single phase motor is used, this can be achieved only by an application of special transformers. Direct current motor traction also lends itself but poorly to power recuperation. On the other hand, in thermo-electric systems of drive, with an electric buffer system, recuperation of energy, owing to the reversibility of the buffer dynamo, is extremely easy. When the car runs down an incline, the speed of the engine tends to increase, and the voltage of the dynamo increasing likewise and becoming superior to the voltage of the storage battery, produces an automatic flow of energy from the dynamo into the battery. If at the same time in some way, such as by an automatic application of a solenoid governor, the supply of fuel to the motor be cut off, then the kinetic energy liberated at the rim on account of the downward run, is sent into the storage batteries by means of the dynamo, a direct transmission, i.e., with an efficiency of at least 80 per cent. The same thing happens during the slowing up with the kinetic energy resulting from inertia of the car. It must be further borne in mind that this recuperation does not require any supplementary installations on the car, but automatically follows from the operation of the motive and governor elements of the driving plant, the only duty of the motorman

being to keep the controller in such a position as to maintain the schedule speed of the car.

The author appreciates the importance of the recuperation of energy which may be obtained with thermo-electric cars provided with an electric buffer, and considers as an example a line 4 km. long with an average amount of irregular ground so that, say, $\frac{1}{2}$ of the length is flat while the other contains uneven ground, in spots, down grade of an average fall of about 30 mils. The total gradient of these parts of the line, downwards, will be $2000 \times 0{,}030 = 60$ m.

Assuming now that the average coefficient of traction for the motor car and trailers is 8 kg. per ton (16 lb. per short ton), and that it is necessary to drive on this line a train of 40 tons (44 short tons), including the motor car, with an average speed of 50 km. per hour and at a minimum speed of 25 km. per hour on the above defined inclines. Then the power at the wheel rim is:

On flat ground:

$$P = \frac{(40 \times 8)50{,}000}{3600 \times 75} = 60 \text{ h.p. (in round figures).}$$

On the incline (30 mils):

$$P = \frac{(40 \times 38)25{,}000}{3600 \times 75} = 140 \text{ h.p.}$$

In order to be able to perform the work to meet the above requirements with an electric transmission motor car having an efficiency of 60 per cent, it would be necessary to have an engine of about 240 h.p., which on the even ground, i.e., over $\frac{1}{2}$ of the total run, would have to deliver only about 100 effective h.p., or about 60 h.p. at the rim. With a car provided with electric buffer dynamo, an engine of 120 h.p. would prove fully sufficient, the additional power required on the heavy up grades being supplied by the storage batteries. It is evident that in this case, the internal-combustion engine will be utilized to much greater advantage than in the case of the first, since its normal output would be close to the average output required by the line conditions.

The author's calculation (not suitable for abstracting) establishes the remarkable fact that energy recuperation during slowing up is practically twice the energy recuperation during down-grade runs, which shows that the use of the internal-combustion engine drive with buffer dynamo is of value not only on lines of irregular ground, but also on lines where frequent stopping or slowing down is required. It is a well-known fact that such slowing down operations are quite frequent even on trunk lines. His figures show that the net recuperation at the rim will be, under the normal conditions of operation assumed, about 28 per cent of the total power necessary for starting and traction purposes. The author discusses further in detail the problem of the use of the storage battery on such cars and the various fuels that may be used. He considers also the cost of operating the cars and gives a table showing the work required per ton-km. under various conditions and amount of standard fuel consumed. He comes to the final conclusion that even when utilizing comparatively expensive fuels, such as benzol, traction proves to be more economical with internal-combustion engines than steam locomotive, both on branch lines and for light trains on secondary lines of the Belgian trunk systems. From the cost point of view, the internal-combustion locomotive is inferior to the electric traction, but the use of cheaper fuels promises to change this equation in favor of the thermal locomotive. Besides, when the amount of capital employed is taken into account, including depreciation charges of central stations, sub-stations, transmission lines, etc., the difference in the two systems comes down practically to the vanishing point. In addition, it must be remembered that the thermo-electric drive presents the greater advantage of being carried on by independent units exclusively, so that it may be, without loss, placed in service on new lines or adopted by old ones. Further, its use eliminates entirely the many chances of accident which always threaten the operation of complicated electric traction systems and which, when they happen, may put an entire section of the system out of business.

The author believes that in many cases, these advantages will be sufficiently important to compensate for the slight excess in cost of the thermo-electric system of drive over the purely electric. The rest of the article is devoted to a detailed description of the thermo-electric motor car with means for recuperation of energy.

Measuring Apparatus

OPTICAL AMPLIFYING TORSION METER (*Torsiometro ottico amplificatore*, A. Anastasi, *Rendiconti delle esperienze e degli studi eseguiti nello stabilimento di esperienze e costruzioni aeronautiche del Genio*, vol. 3, no. 2, p. 48, April 30, 1914, 3 pp., 2 figs., *d*). The present article describes an optical torsion meter with amplification. The apparatus belongs to the class of electro-optical torsion meters and has been designed by A. Anastasi, engineer of the Italian military aeronautical laboratory. It consists essentially of two drums, t_e and t_i, one inside the other, with a very small interstice between them. Each one is rigidly affixed to one of the two sections A and B, respectively, of the shaft, the torsion of which it is desired to measure (Fig. 1). The interior drum is provided with a certain number of small slots f_i, parallel to the axis of the shaft and exactly equidistant from one another. The exterior drum is provided with a similar number of helicoidal slots f_e of equal dimensions and as equally equidistant. Inside of both drums is located a luminous source, in this case an electric lamp L, carried on a fixed plane. External to the shaft and parallel to it is located a graduated scale R over which can be moved a telescopic sight O, the axis of which is normal to the axis of the shaft. When the shaft is turned, owing to the presence of the internal illumination and in accordance with the velocity of rotation, one may persistently observe the correspondence of the slots in the external drum with those of the internal drum and the position of the plane of correspondence may be determined by taking sights through a

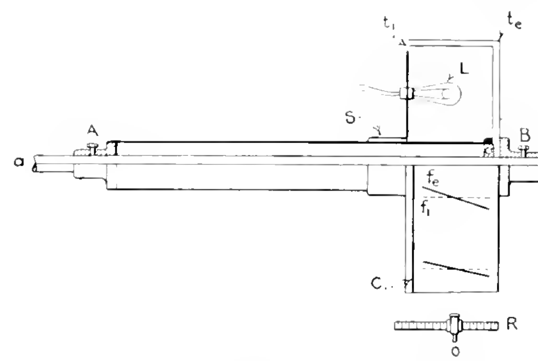


FIG. 1 OPTICAL TORSION METER WITH AMPLIFICATION

telescope. The displacement of such a plane from its normal position of rest is proportional to the torsion of the shaft, or more correctly, to the maximum of the effort transmitted, and can be read correctly on the graduated scale E. To this device is added a similar device having for its purpose the amplification, longitudinally, of the relative displacement of the two corresponding points of the two drums, without using any amplifying mechanism. In order to eliminate the perils arising from an eventual shifting of the shaft, it is well to refer the position of the plane of correspondence of the slots not to a fixed origin on the scale article, but to positions on a circle C, plotted inside of the external drum.

The above described torsion meter can be used even when the effort transmitted by the shaft is not exactly constant, provided its variations be not too large. In this case, the crossing of the corresponding slots can be seen from the side of the scale, not in the fixed position, but oscillating between two extreme positions between which it is easy to determine a medium point. The apparatus may be conveniently applied at high but not extreme velocities, since the drums with their slots would not be able to withstand a very great centrifugal force. This, however, may be obviated to a certain extent, by using drums made of a light metal, properly disposing

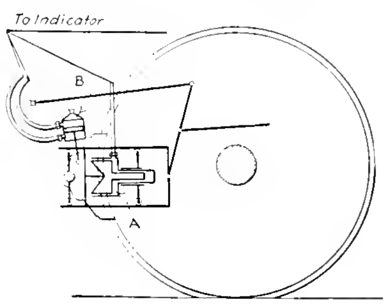


Fig. 2 Brake Action Indicator

the thickness of the material and number of slots, and perhaps reinforcing the entire structure by a helix of steel wire. On the same principle may be constructed the torsion meter comprised instead of two drums, of two discs, one having radial slots and the other a slot made on an archimedean spiral, with a similar lamp and scale arrangement.

Four Axle Dynamometer Car, Swiss Federal Railways (*Vierachsiger Dynamometerwagen der Schweizerischen Bundesbahnen*, H. A. Gandy, *Schweizerische Bauzeitung*, vol. 64, no. 6, p. 73, August 8, 1914, serial article, *d*). The article describes a four-axle dynamometer car recently built for the use of the Swiss Federal Railways. Among the apparatus with which it is fitted is a device designed by the well-known firm of scientific instrument builders, Brothers Amsler, in Germany, for indicating the braking action and its effects. The apparatus is shown in Fig. 2. For the determination of tangential and radial forces arising through the pressing of the brake shoe against the wheel rim, a hydraulic measuring cylinder is inserted into the rigging. On the front axle of one of the bogies, two such measuring cylinders are built in on the brake hangers of the front brake traversers, while one more measuring cylinder, located horizontally, transmits the brake rigging forces acting on the middle of this traverser. The fluid pressure occurring in these three cylinders during the braking is transmitted to an indicator placed over the apparatus table and recording the pressure diagram on a strip of paper. In this way, two diagrams, one for the tangential and the other for the radial forces, are obtained, and by using the values given by the diagrams, the friction coefficient for any given velocity may be determined.

The same arrangement may be further used for determining from the frictional data obtained above the value of the material used in the brake-shoe. The measurement of the tangential forces may be carried out with the car moving in either direction as there is an arrangement for connecting either end of the measuring cylinder with the recording device. In addition to this device for the measuring of the braking forces in the rigging, there are further provided three indicators for the determination of the air pressure prevailing during the braking process in the main line, the brake cylinder and the auxiliary air tank. While these devices record the pressure diagrams on paper strips, the

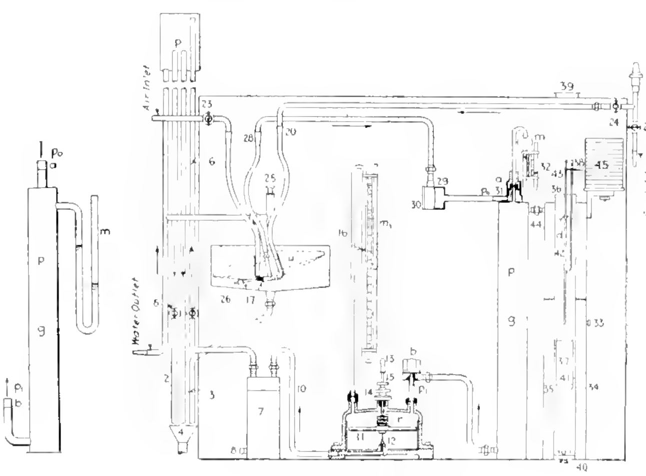


Fig. 3 Densograph

manometers, connected with the indicators, make it possible to read the instantaneous values of the pressure; and two further recording devices take care of the braking length as well as the braking time, the latter being recorded at intervals of 1, 3 and 6 seconds. By means of the above apparatus, the following observations therefore can be taken: (1) pressure in the brake cylinder; (2) pressure in the auxiliary air tank; (3) pressure in the main line; (4) brake-shoe pressure (radial force); (5) tangential force; (6) coefficient of friction of the brake-shoe; (7) time of braking; (8) braking length.

Densograph (*Der Densograph, Professor Hugo Strache, Zeits. des Vereines der Gas- und Wasserfachmänner in Österreich-Ungarn*, vol. 54, no. 10, p. 190, May 15, 1914, 10 pp., 5 figs., *de*). The present article describes a densograph, an apparatus for constant and automatic recording of the specific weight of gases. The usual apparatus for the determination of the specific weight of gases, invented by Schilling, is based on the assumption that the time during which a certain volume of gas flows under a certain pressure through an opening in a thin sheet is proportional to the square root of the specific weight of the gas, but this device, remarkable for its simplicity, has the serious disadvantage of not permitting of making a constant record of the specific weights of the gases and in view of this defect the apparatus

cannot be used for constant records. In addition to that, there is a second very important defect in this apparatus, consisting in that a single observation did not permit of a simultaneous determination of a number of other factors, the knowledge of which would allow of making a clear conception of the processes occurring. There are, of course, a number of apparatus which permit a continuous weighing of gases, but their operation is liable to be interrupted by numerous disturbances from which the densograph is claimed to be safe. It consists (Fig. 3) of the vessel g, initially filled with air into which the gas enters through a small plate a provided with a tiny opening. The gas is forced through it pump, etc. In order to obtain correct indications it is necessary to maintain the gas and air under equal pressure. The apparatus may be used for coal gas, furnace gas and balloon gases as well as for various other purposes such as the determination of the specific weight of producer gas, etc.

New Apparatus for the Determination of Pressure, Velocity of Flow, Density and Composition of Gases and Vapors (*Neuere Messgeräte zur Bestimmung des Druckes sowie der Geschwindigkeit, Dichte und Zusammensetzung von Gasen und Dampfen*, E. Stach, *Glückauf*, vol. 50, no. 31, p. 1233, August 1, 1914, 5 pp., 15 figs. *d*). The

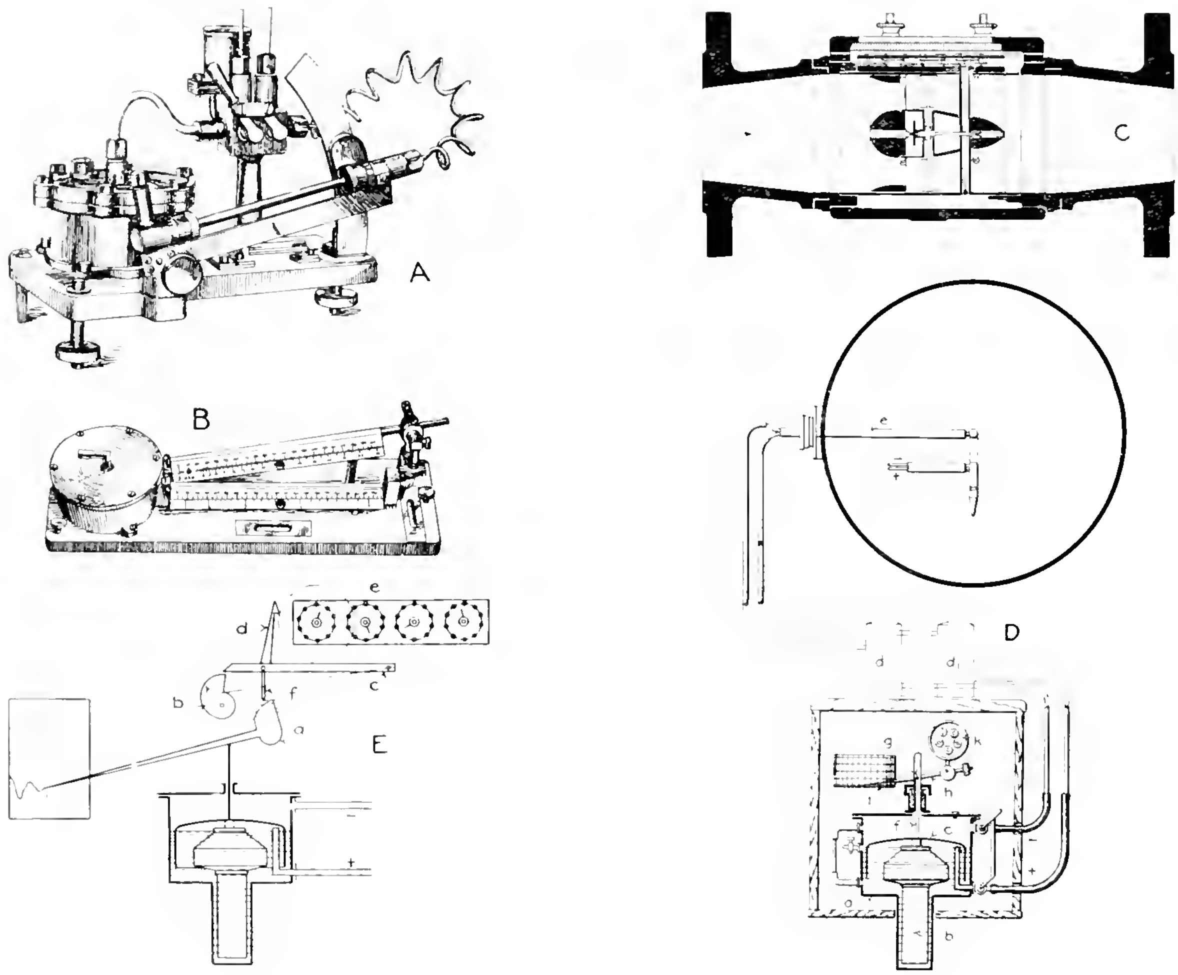


Fig. 4 Various Measuring Apparatus for Gases

by means of a suction device and a plate similar to that at a, located at b. If the same gas passes through a and b, then the suction inside the vessel is equal to $\frac{1}{2}$ the total suction. If, however, into the air filled vessel there flows a gas lighter than air, then the resistance at a will be less and the suction in g goes correspondingly down. By this method, a manometer or recording suction meter may be operated; as soon as the gas displaces the entire air and gets as far as b, the initial manometer stand will come back. The densograph is made to give a continuous record by including in the apparatus a special device which permits the taking in of gas and air in an established rotation of operations. In addition to the parts shown in the figure, there are several more pumps such as the above mentioned device for sucking in air, a water pump, a governor to regulate the suction of the article describes novel apparatus for the determination of pressure, velocity, density and chemical composition of gases and vapors, including the manometer of Dr. Verbeck, which has vertical tips and two liquids of different densities. The upper parts of the glass tube tips are arranged concentrically in order to avoid possible errors in case the manometer is not placed in an exactly vertical position.

As regards micromanometers, Füss builds them now for pressures up to 30 atmospheres, Fig. 4A, with mercury, for measuring pressure of gases and water in closed pipes. In the case of permanently built-in micromanometers with rigidly fixed measuring tubes, there may be a demand for measurements over a wide region of pressures such as cannot be served by a single permanently built-in measuring tube. For this purpose, Rosenmüller has designed the mano-

meter shown in Fig. B, with two permanently built-in measuring tubes covering different regions of pressures, so that when the velocity passes the limits of the upper tube, the lower tube may be used for the measurement. As regards anemometers, only deadbeat types are now used while the improvement of clockwork devices has made clockwork anemometers more reliable and more widely used.

For the measurement of high air velocities such as occur with fans, cup anemometers are often used instead of wing anemometers as being more suitable for this kind of work. For the measurement of compressed air, Rosenmüller builds the wing anemometer shown in Fig. C, which is built-in in a special measuring chamber forming part of the compressed air piping and having an indicating device on the outside.

For recording the velocity of the flow of gas, the arrangement shown in Fig. D, and designed by Füss, is said to be especially convenient, since it has succeeded in using the same scale even for low velocities up to 5 mm. per sec. with a great sensitiveness of indication. In a metal vessel, *a*, there floats in a liquid a specially shaped body *b*, provided with diving bell *c*, which divides in two the air space over the liquid. The spaces thus formed are connected by means of pipes or hose with the air tanks *d* and d_1, which are in their turn connected with the Pitot tube *e*. The large area of the diving bell insures a high sensitiveness of the apparatus while the tapered formation of the head of the float produces an equal rise of the entire structure out of the water. In order to transfer the motion of the float without friction and without the use of any packing, to the recording apparatus, an iron piece *g* is set on a brass spindle *f*, surrounded by a brass pipe, well screwed on to the cover of the device. Around this brass pipe is located a magnet resting on the lever *h*. The stylus *i* then shows the velocity occurring at the instant. By means of the counter device *k*, the amount of gas flowing through the pipe or passage can be read direct.

The clever arrangement of this counter-device is shown in Fig. E. The end of the lever carrying the magnet is provided with a graphite piece *a*, the shape of which has to be established experimentally so as to be in accordance with the section of the measuring tube. A small clockwork arrangement releases at short intervals of time another clockwork device which in its turn releases lever *c*. This allows during the test of the fall of the pawl device *d* of the counter *e*.

And lever *c*, during the period of its fall, actuates the clockwork *e* through the pawl *d*. The motion of *d*, and accordingly the indication of clockwork, depends on the position of the curved piece against which strike the caliper-shaped piece *f*. With gases of constant density and temperature, an agreement as close as 1 per cent has been obtained between measurements by planimeter and the described apparatus.

Steam Engineering

Triple-Flue Boiler Plant (*Eine Dreiflammrohr-Kesselanlage*, Föge, *Zeitschrift für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 33, p. 398, August 14, 1914, 2 pp., 5 figs., *d*). The article describes a triple flue boiler plant installed lately in a textile plant at Linden, Germany. Recently, the former power plant of the factory became insufficient to take care of the increased output, while the limitations of space did not allow of an increase of equipment by installing more units. The only thing that remained therefore was to take out the existing equipment and to put in new units which would, with the same amount of space, produce a substantially larger output of steam. While the use of water tube boilers would solve this problem sufficiently well it could not be resorted to on account of the extremely bad properties of the water in the river Ihme, from which the boiler feedwater was taken. After careful consideration of the situation, the use of very large triple flue boilers was decided upon and units were selected having 155 q.m. heating surface and producing steam at 12 atmospheres pressure, 300 deg. cent. (540 deg. fahr.) super heat, the feedwater being previously preheated to 110 deg. cent. (230 deg. fahr.) in a cast-iron cylinder of the Green type. Fig. 5 shows the way the installation was effected.

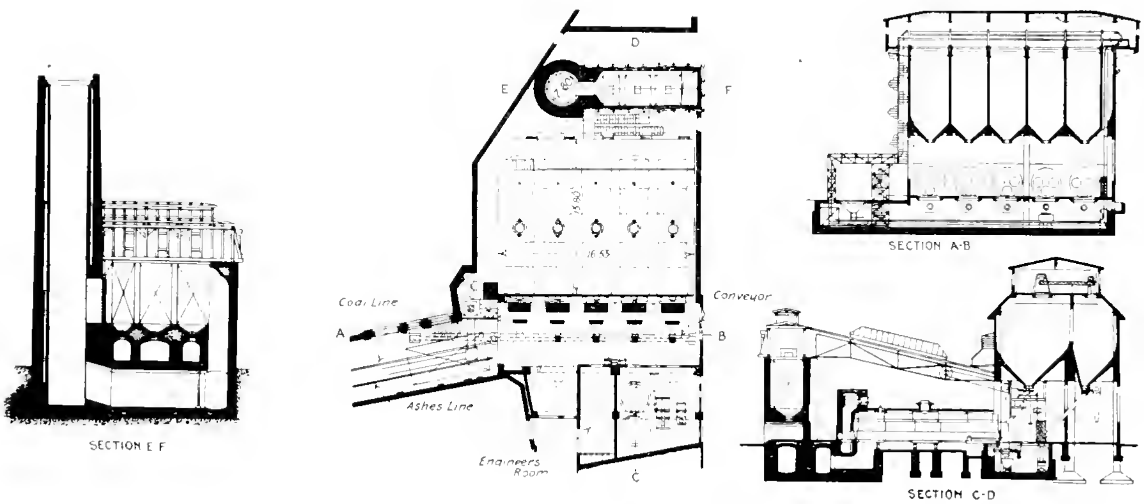


Fig. 5 Triple Flue Boiler Plant

New Evaporation Apparatus for the Production of Distilled Water (*Ein neuer Verdampfapparat zur Erzeugung von distilliertem Wasser*, H. W. *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 30, p. 367. July

42, 1914. 1 p., 1 fig. *d*). The article describes a new apparatus for the production of distilled water. The apparatus, built by the Balcke Machine Company of Bochum, Germany, differs from other types now on the market in that it compresses a part of the steam of evaporation by means of live steam and in this way enables the former to take part in the further evaporation process, the compression being effected by means of what the author calls a "thermo-compressor." This is nothing but a steam jet apparatus of peculiar construction, possessing an exceptionally high efficiency, and is the most important part of the apparatus; the latter delivers distilled water ready for actual use.

The general construction of the apparatus is shown in Fig. 6. It consists of the raw water tank *A* and preheater *B*, thermo-compressor *C* and vaporizer *D*, in addition to which there are of course piping, condensers and a wrought iron frame. The vaporizer works by means of live steam which is led on to the thermo-compressor after it has gone through the water separator *W*. A part of the live steam carries over by suction from three to four times its weight of steam from the evaporation chamber *K* of the vaporizer, the compressed steam mixture passing then into the vaporizer chamber *D*. Here the steam mixture is condensed and gives up its heat to the distilled water, which is equivalent to producing from the water to be distilled, an amount equal to its weight of steam of evaporation. If now one part of live steam compresses four parts of steam of evaporation, in five parts by weight of the steam mixture reaching the vaporizer chamber, it will convert five parts by weight of water into a similar weight of steam of evaporation. Out of these five parts, four are carried by suction through the thermo-compressor, conducted into the steam chamber, and there condensed, while the fifth part goes into the preheater *B* and preheats there the entire water which is to be distilled to nearly 100 deg. cent. (212 deg. fahr.). It appears that when water starts with an initial temperature of 10 deg. cent. (50 deg. fahr.), this amount of steam is just sufficient for doing that work. As a result, therefore, the total steam of evaporation is condensed, four parts in effecting further evaporation and one part in the preheater, and the water of condensation, which is in this case also the distillate, is conducted into the storage tank and used for any purposes that may be required.

General Considerations Concerning Condenser Air Pumps (*Considérations générales sur les pompes à air des condenseurs*, A. Delas. *Mémoires de la Société des Ingénieurs Civils de France*, ser. 7, vol. 67, no. 5, May 1914, p. 585. 11 pp., 13 figs. *d*). The article describes various air pumps used in connection with steam turbine plants. It is mainly of historical and descriptive nature and presents general considerations on the construction of apparatus, otherwise well familiar to American engineers, such as the Leblanc rotary jet pump and the Delaporte ejectair (for the latter see *The Journal*, July 1913, p. 1183).

ENGINEERING SOCIETIES

AMERICAN FOUNDRYMEN'S ASSOCIATION

Advance papers of the Annual Meeting in Chicago, September 7-11, 1914.

Remarks on the Strength and Ductility of Malleable Cast Iron After the Skin has been Removed, Enrique Touceda (abstracted)

The Selection of Grinding Wheels for the Foundry, C. F. Dietz

Elimination of Waste Motion in Bench Molding, R. E. Kennedy and J. C. Pendleton

Researches in the Annealing Process for Malleable Castings, Oliver W. Storey

General Melting Characteristics of Acid Steel for Castings, A. F. Stirling Blackwood

Safety and Sanitation in the Brass Foundry, F. Moerl

Remarks on the Strength and Ductility of Malleable Cast Iron After the Skin has been Removed, Enrique Touceda (13 pp., 3 figs. *pe*). This article discusses the question of the strength and ductility of malleable cast iron after the skin has been removed, and combats the idea that, after the skin has been removed, the remaining metal is of inferior quality, if not absolutely worthless. As regards the structural composition of good malleable iron, one must bear in mind that, if it has been properly annealed, its structure must consist of ferrite and free carbon, and with

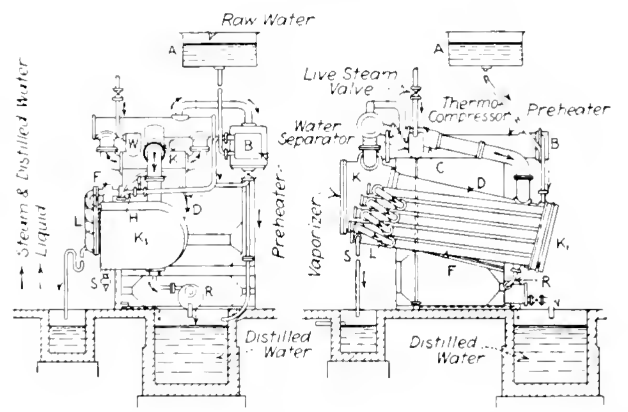


Fig. 6 Evaporation Apparatus for the Production of Distilled Water

the exception of the ferrite in the rim, the ferrite in the rest of the piece is contaminated more or less with free carbon, so that, with two exceptions, the structural compositions of wrought and malleable iron are in the main identical. One of these exceptions is that the ferrite of the malleable iron is higher in silicon than that of the wrought iron, but that affects neither the ductility nor the size of the crystals of the ferrite. The other exception results from the presence of free carbon in the ferrite of malleable iron, which may affect the strength of the iron and ductility of the material where it occurs in concentrated form, in patches. As regards the skin, it appears that if the annealing process has been arrested at the exact moment when the last trace of free or pearlitic cementite in the casting has been broken up into ferrite and free carbon, there will be around the edge of the casting a rim about $^1/_{32}$ in. deep of practically carbonless iron. The structure of the balance of the section is very uniform throughout. The author discusses at certain length the influence of the rim on the strength of the bar and its elongation, and while he admits that the rim can add greatly to the final strength of the bar, he questions the possibility of its affecting the elongation, at least affecting it favorably, and comes to the conclusion that any record of elongation on a malleable iron test bar expresses elongation of the metal *in the core only*, as the metal in the rim is capable of further stretching.

The author during the past few years has made numer-

ous physical tests on malleable cast iron, and he noticed that defects nearly always exist in the bars such as are usually made for tensile tests, due to the unsoundness caused by shrinkage or faulty contraction as the case may be. Many test bars are made with a reduced section either to enable the grips of the machine to hold the specimen better or to force the bar to break outside the grips. A bar cast in this manner is nearly always defective, due to the inability of the iron to set normally. In bars of uniform section throughout, defects are frequently found to exist at the central portion of the bar. In experiments to determine the difference in strength between skin and core, often as much as 1/16 in. of the stock is removed in the finishing cut all around the bar which represents perhaps 30 per cent of the original area and sometimes even more. If the region around the center of the test bar is unsound, the data of such a test can give no information as to the relative strength of the metal in skin or core. In order to determine the relative strength of machined pieces and pieces with the skin on, dynamic tests were made with the following results:

AFTERNOON HEAT OF JUNE 3	
Unmachined wedges	Machined wedges
Average of 4 tests, 18.5 blows	Average of 4 tests, 13.2 blows
AFTERNOON HEAT OF JUNE 4	
Unmachined wedges	Machined wedges
Average of 4 tests, 29.75 blows	Average of 4 tests, 26.3 blows
MORNING HEAT OF JUNE 6	
Unmachined wedges	Machined wedges
Average of 4 tests, 19.75 blows	Average of 4 tests, 21.2 blows

The author discusses in further detail the question as to why he selected for the test purposes bars in the form of wedges, a shape which appears to give good results for this particular purpose.

Elimination of Waste Motion in Bench Molding, R. E. Kennedy and J. Pendleton (10 pp., 4 figs. *dp*). The article describes methods of elimination of waste motion in bench molding. In studying the conditions existing in an ordinary foundry, the writer has found a considerable amount of wasteful lost motion due to an inconvenient arrangement of the bench, and it was found best to have the benches made of the wall type, even though in a great majority of cases a portable bench over the sand pit is most economical, due to the reduced handling of sand and mould. On the bench shown in Fig. 7, the arrangement is such that the tools have to be placed in the proper places and the foreman or molder can see at a glance whether the tools are all in proper condition. Every tool can be seen at once, so that there is practically no loss of time in searching for it on the bench. The tool box is returned to the tool room each evening, when the condition of the tools may be inspected. Special tools are placed in the box issued to the molder assigned to a particular job where they are required, and the bench cannot then be littered with a mixture of tools, patterns, old cores, etc. The two brackets marked *AA* are to hold the cope when no patterns are to be drawn from it.

AMERICAN INSTITUTE OF MINING ENGINEERS

July 1914, New York City

Draining Kerr Lake, Robert Livermore
Nodulizing Blast-Furnace Flue Dust, Lawrence Addicks (abstracted)
Basic-Lined Converter Practice at the Old Dominion Plant, L. O. Howard

August 1914

Melting of Cathode Copper in the Electric Furnace, Dorsey A. Lyon and Robert M. Keeney
Tests of Rock Drills at North Star Mine, California
Rope Idlers in the Raven Shaft, George A. Packard
Electrical Fume Precipitation at Garfield, W. H. Howard
The Annealing of Cold-Rolled Copper, Earl S. Bardwell (abstracted)
Curves for the Sensible Heat Capacity of Furnace Gases, C. R. Kuzell and G. H. Wigton

Nodulizing Blast Furnace Flue Dust, Lawrence Addicks (July 1914, 4 pp. *cp*). The article describes a process used at the refinery of the United States Metal Refining Company, Chrome, N. J., where a large amount of unsmelted blast furnace flue dust has been accumulating and some scheme had to be devised for usefully taking care of this material. After a careful consideration of the problem, the process of nodulizing was decided upon. The kiln was approximately 2 ft. in diameter and 20 ft. long and was fired with fuel oil, the consumption being about 50 gal. of oil per ton of flue dust. Later, a larger kiln, 60 by 6 ft. was decided upon with a 6 in. brick lining. With the test kiln, there was a decided tendency to the formation of nose rings, and it was found that to avoid them a steady condition of flame was very necessary. Trouble was also experienced because of a formation and subsequent plastering of sand on the walls through overheating of the kiln. This could be obviated only by skill and care on the part of the attendant. As regards the comparison of nodulizing with blast roasting, it was found that the former was entirely independent of the necessity of having a properly balanced internal fuel supply.

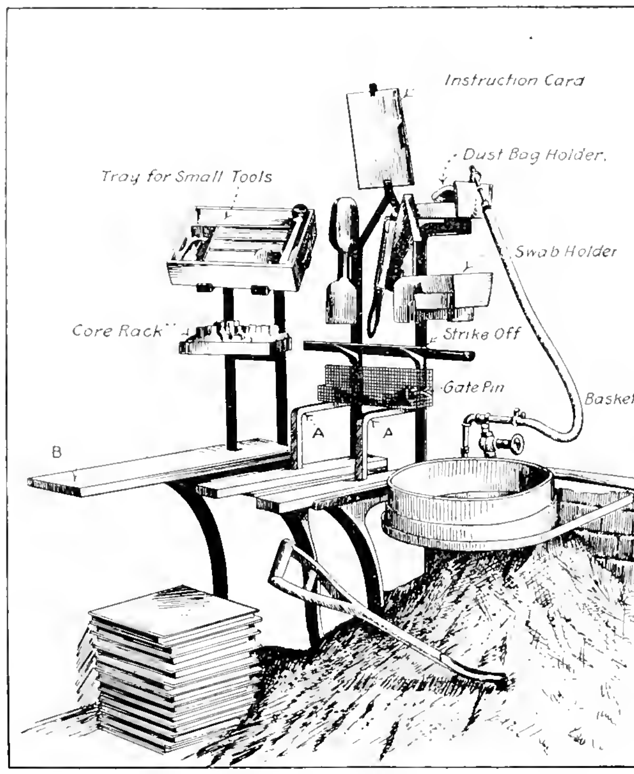


Fig. 7 Molding Bench

As far as the operating cost goes, the cost of fuel is the deciding element. A single operator can attend to the firing of several kilns, and the repairs should be small as

the machinery is simple, thoroughly standardized, and not exposed to the heat.

The Annealing of Cold-Rolled Copper. Earl S. Bardwell (20 pp., 20 figs. eA). The author discusses the annealing of cold-rolled copper with respect to the effect of annealing temperatures on physical properties and changes in the microstructure of refined copper due to cold-rolling and annealing. As regards the former, the test bars were selected with the contents of copper and silver together from 99.93 to 99.95 per cent and varying in oxygen contents between the limits of 0.036 and 0.070. The tensile strength of copper wire annealed at various temperatures is given in the article both in the form of tables and curves. It was figured out by multiplying the breaking weight in pounds by the reciprocate of the cross-section area in square inches. As the temperature of annealing increased, the tensile strength pretty uniformly went down from 63,000 to 65,000 lb. at a temperature of annealing of 60 deg. fahr. to about 35,000 lb. at 1000 to 1100 deg. fahr., and then began slowly to rise from 37,000 to 39,000 lb. for a temperature of 1800 deg. fahr. On the other hand, the percentage of elongation reached its maximum at about 1300 deg. fahr. The author compares his results with the results obtained by the French investigator, Capt. C. Grard, whose results differ materially in some respects from those obtained by the author, but this article goes further into detail with respect to the changes in the microstructure of refined copper due to cold-rolling and annealing. It is found that the temperature at which strained metal is annealed seems to exert considerable influence upon the formation of polysynthetic twin crystals as well as upon the size of the crystals in general. The increase in the size of the crystals is accompanied by a decrease in the per cent of elongation, which is of interest since a piece of annealed metal having a maximum per cent elongation is in the best physical condition for withstanding further mechanical treatment. As regards the trouble caused by over-heating copper in the annealing furnace, it appears that over-heating facilitates the development of polysynthetic twin crystals and results in a decrease of the per cent elongation. Sheets which have been overheated in this way give trouble by cracking at the edges. If the annealing temperature is very high, gases which are unable to escape when the metal is cast, tend to segregate at the granular boundaries. Overheating the copper previous to the breaking-down rolls, as a rule, results in blisters. When the annealing temperature becomes so high that the metal begins to soften, the gases contained in the metal tend to force the grains, thus causing cracks into which the oxygen in the atmosphere penetrates.

Bulletin, September 1911, New York City.

Curves for the Sensible-Heat Capacity of Furnace Gases, C. R. Kuzell and G. H. Wigton

The Surface Decarbonization of Tool Steel, J. V. Emmons (abstracted)

Coal-Dust Explosion Investigations, M. J. Taffanel

Rolled Steel Roll Shells, James C. H. Ferguson

Finishing Temperatures and Properties of Rails, George K. Burgess, J. J. Crowe, H. S. Rawdon, R. W. Waltenberg

Manganese Steel and the Allotropic Theory, Albert Sauveur

The Surface Decarbonization of Tool Steel. J. V. Emmons (15 pp., 13 figs., eA). The article discusses surface decarbonization of tool steel. The phenomenon itself has been observed before, but the origin and effects of it have been but little studied. In order to investigate the reaction occurring in the surface decarbonization and to determine the rate at which it proceeds at various temperatures, pieces from a bar were annealed in a strong current of pure dry carbon dioxide at various temperatures, after which a microscopic examination was made of the cross-section and the depth of decarbonization measured by means of a micrometer eye piece. For greater ease and accuracy, it was measured only from the surface to the point of supersaturation or to the point where free cementite first made its appearance. In all these experiments, decarbonization has been effected by oxygen in the form of a gas. In order to determine if it is necessary for the oxygen to be in the form of a gas to combine with the carbon in the steel a crucible of lead was saturated with lead oxide by the addition of litharge. The test piece was annealed in it for three hours at 1500 deg. fahr., after which a microscopic examination revealed decarbonization to a depth of 0.024 in., which shows that easily reducible oxides when dissolved in a metal bath may also effect the elimination of carbon. The experiments have on the whole shown that carbon is removed from steel by a process of oxidation which may be effected either by gases or liquids; that among bases, the principal active agents are air, carbon dioxide and water, while as to the liquids, any good oxidizing agent dissolved in a liquid bath may be the active agent. During the annealing, carbon dioxide necessary for the elimination of carbon may be formed through the reduction of iron oxide by carbon monoxide, but no case has been observed where carbon was eliminated while the steel was heated below its critical point, which proves that carbon must be dissolved in the iron before decarbonization can take place. The rate of decarbonization under uniform conditions is constant without regard to the depth to which it has proceeded. This would tend to indicate that the carbon is transferred from the interior to the surface by diffusion toward the solid solution.

The practical importance of decarbonization of tool steel lies in the difficulty of machining what is known as "bark" or the decarbonized surface, which must be removed before the steel can be used for cutting tools, wearing surfaces, etc. The depth of the bark may vary greatly, owing to oxidizing conditions during the hammering, rolling and annealing of the rough material. The common method of determining the thickness of the bark is by examining the hardened fracture by means of the naked eye or under a magnifying glass. The bark shown is coarser grained than the high carbon interior. The author has made a number of experiments to determine the reliability of this method, the data of which will be found in the Table 1, p. 0199. From it, it appears that with the increase of temperature there is an increase in the amount of bark, due obviously to the fact that an increased amount of cementite is held in solution by quenching from the higher temperatures. The method of inspection by the naked eye or under a magnifying glass is therefore reliable only when the hardening heats are carefully regulated and the results frequently checked by microscopic examination. The most reliable method of inspection is by microscopic examination of an annealed specimen in which case the measurement of the depth of decarbonization may be made with a micrometer eyepiece.

In the machining of tool steel, the bark presents serious difficulties which increase still further when the machining is done in such a manner that only a part of the layer of coarse pearlite is removed. In this case the surface of the work will be rough and the point of the tool worn out with great rapidity. The cause of the appearance of a layer of coarse crystals is the difference between the critical points of eutectoid and hypereutectoid steel, the eutectoid steel being at the correct temperature for annealing, while the hypereutectoid steel is far enough above its critical point to allow the crystallized grains to grow to a considerable size. The cause of the hard wear on the cutting tool when encountering bark formation is due to the way the tool cuts, viz., the fact that when removing a chip from a piece of metal, it splits it off by an action similar to a wedge so that the hardest work of the tool occurs not at the extreme point, but a short distance back from the point where the pressure of the chipping is greatest. There is therefore always a crack running ahead of the tool as it is forced through the material which is being cut, but when the tool is cutting in coarse pearlite, this crack will follow the lines of least resistance which in this case are the boundary lines of the grains and through the grain in the direction of the laminations. The larger the size of crystalline grains, the more irregular will be the crack and the rougher the resulting surface. Now the rough surface left by the crack running ahead of the tool increases the amount of work and friction on the extreme cutting edge, the point of the tool being obliged to rub over the protruding grains of pearlite and to tear out some of them entirely. This is intensified by the great abrasive quality of the cementite when held by alternate plates of ferrite. The case becomes even worse when the bark consists of a band of coarse hypereutectoid steel below the band of coarse pearlite, in which case the coarse grains of pearlite are bound by a cementite underwork which seems to add greatly to the difficulty of machining. That the bark has to be removed there can be scarcely any doubt, since when a piece of steel is hardened the surface is hardened only in proportion to the carbon it contains. Since, further, in the great majority of cases where tool steel is used, it is the edge that takes up the most severe work, the presence of the bark would rapidly produce blunt edges in tools, undersized in reamers and twist drills, or over sized in dies.

TABLE 1 DEPTH OF BARK AS A FUNCTION OF TEMPERATURE OF HARDENING

Temperature of Hardening, deg. fahr.	Depth of bark, inches
1370	0 015
1380	0 018
1390	0 018
1415	0 018
1435	0 021
1460	0 020
1490	0 024
1530	0 027

AMERICAN SOCIETY OF CIVIL ENGINEERS

Proceedings, vol. 40, no. 6, August 1914, New York City.

External Corrosion of Cast Iron Pipe, Marshall R. Pugh (abstracted)

The Design and Construction of Four Reinforced Concrete Viaducts at Fort Worth, Texas, S. W. Bowen

The Clarification of Sewage by Fine Screens, Kenneth Allen

External Corrosion of Cast Iron Pipe, Marshall R. Pugh (50 pp., 21 figs. *gp*). The discussion of conditions where special protection of cast iron pipes against external corrosion is needed and suggestions of preventive methods adopted to different cases, forms the chief part of this article. The author takes up in considerable detail cases where cast-iron pipe proves extremely durable as well as where it deteriorated very rapidly. He mentions the acid and electrolytic theories and shows that among the conditions contributing to corrosion, the following may be mentioned.

The rate of corrosion has been found to increase in proportion to the increase of free carbonic acid. Cast iron subjected to slow action of dilute acids, as for example acid water from mines, retains unchanged the external shape of the casting, but the composition of the metal is altered, iron being removed in solution. Rain water, particularly in thunderstorms, contains nitric acid or nitrates which may also be present in polluted waters; potassium nitrate or potassium sulphate have been found to produce strong corrosion; magnesium and ammonium chlorides (the form found in sea water) corrode iron even in the absence of air. Oxygen plays a very important part in corrosion. The rate of motion of water also has a bearing on the rapidity of corrosion, as under certain circumstances it brings a constantly renewed supply of air to the rusting metal. The action of living matter has likewise to be taken into consideration for, although the direct action of any organism is doubtful, it is possible that certain living organisms secrete acids which lead to corrosion. This applies both to the animal kingdom and humic acids. In certain places, for example in Southern Illinois, the soil shows a marked acid reaction, and when it does, it produces a material intensification of corrosion of steel structures. When this acid content exists only to a certain depth, steel buried at a greater depth does not seem to exhibit any unusual tendency to corrosion. The author discusses also the conditions of inhibiting corrosion, such as the effect of concrete, siliceous scale on cast-pieces, the presence of small quantities of chromium, nickel and copper in the iron, the presence of phosphorus and the coating of iron with zinc or tin. He discusses a number of cases of deterioration of cast-iron pipe. Among the recipes to prevent rusting of iron, he quotes one given in the year 1790, which is as follows:

"Fry a middling eel in an iron pan, and when brown and thoroughly fryed, express its oil and put into a phial, to settle and become clear in the sun. Iron annointed with this oil, will never rust, although it lay in a damp place."

The more modern method which the author recommends is resorting to the improvement of the skin resistance of the metal. The use of lime in the trenches so as to encase the pipe in an inhibiting alkali is also recommended. Leaving the pipe in an open trench might also be a help as the alternate wetting and drying would probably be preferable to a constant exposure to moist air, salt and carbonic acid in the swamp soil. At Atlantic City, the cast-iron water mains across the salt marsh have been raised above the surface of the middle of the marsh so that they are entirely in the air. In certain cases it is advisable to galvanize cast iron instead of giving it the ordinary bituminous coating. This method has also been used in some instances for the protection of gratings, covers and similar castings. The writer is not aware of its having been applied to cast-iron pipe.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Journal, vol. [illegible], no. [illegible], August 1914, Washington, D. C.

The Engineering Experiment Station, H. G. Bowen (15 pp., 16 figs., *g*). The article presents briefly the results obtained at the Engineering Experiment Station of the United States Navy at Annapolis. This station appears to have definitely proved its value to the United States Navy, as, e.g., it has in some cases materially reduced the price paid for navy supplies. It is conclusively shown that rubber sheet packing is worthless for high pressures and that, for the present, metallic ring packings have no substitute. Tests with respect to gage glasses have shown that the glass of tubular or reflex gages corrodes in high-pressure steam under the usual surface conditions, and if this action continues long enough, the glass will dissolve and finally fail under pressure. The only certain and efficient method of protecting the gage is by covering the pressure side of the glass with a thin sheet of mica which keeps the glass transparent and unattacked as long as the mica covering is intact. Further, it has been found that superheated steam corrodes and does not erode valve fittings, and that monel metal resists this corrosive action better than class *A* or *B* steel.

With respect to lubricants, it has been found that when sulphuric acid is mixed with oil while the latter is being refined, the oil may form a sulphonated product which is not wholly eliminated and may, under sufficient agitation, pressure and temperature, break down into acid and waxy sludges. A specially constructed machine has been provided for testing forced lubrications under service condition and observing their action when mixed with salt water (see *The Journal*, July 1914, p. 152).

The subject of corrosion of packing and boiler plates has been investigated and among other things, the strength of a solution of sodium carbonate, which would render all boiler materials non-corrosive, has been established and a compound has been issued to the service having the following composition:

Calcined soda ash (96 per cent Na_2CO_3) . . . . 64 to 69 per cent
Tri-sodium phosphate (96 per cent Na_3PO_4) . . . . . . 15 to 20.5 per cent
Glucose . . . . 1.5 per cent
Tannic acid (contained in cutch digested with
caustic soda) . . . . 9.0 to 10.0 per cent

The tannic acid is introduced in order to hold the precipitates in suspension and to prevent adhesion of the scale-forming salts to the heating surfaces while the glucose tends to prevent adhesion of any sulphate scales.

The testing of feedwater heaters had quite a large share of attention in the Experiment Station, and reliable data on the transmission of heat in modern feedwater heaters have been developed. Among others there were made a series of tests to determine the rate of heat transmission in B.t.u. per sq. ft. of heating surface per hr. per deg. fahr. temperature difference between the steam and water at water velocities from 35 to 171 ft. per min. and with various shell pressures. Another series of tests was undertaken to indicate the performances of an apparatus as a multipass heater. Among other apparatus tested were boiler feed pumps, forced draft blowers, safety valves and feed meters. One of the valuable results of the work of the Experiment Station is said to be the elimination of material which on short stereotyped tests is satisfactory, but fails in long duration competition, as well as the elimination of undesirable or freak designs.

CANADIAN SOCIETY OF CIVIL ENGINEERS

Transactions, vol. 27, part 2, October to December 1913, Montreal.

Elevator Construction, J. Spelman (10 pp., 23 figs., *d*). The article gives a brief historical sketch of early elevator construction and describes a number of units, mainly in Canada. Among other things, the author states that in the elevator at Victoria Harbor, Port McNicoll, a concrete stack was built which had a good many cracks in it, the reason of which was that there was not sufficient concrete in the stack. Since then, another stack has been erected in which there are no cracks and the theory upon which it was built was to put in enough steel to take the tension if the concrete cracks and then enough concrete to take the tension anyway, so that the tension on the combined section of the concrete and the steel should be large enough to prevent the concrete from cracking, the walls being about twice as thick as those made by the ordinary stack builder.

Some Disregarded Stresses on Joints and Ends of Steel in Reinforced Concrete Construction, H. A. Icke (5 pp., 5 figs., *t*). The author considers the disrupting forces which may occur as the result of the development of different degrees of strain in contiguous parts of the steel, or steel and concrete, especially in lap joints, and while no claim is made to the establishment of a theoretical method of determination of the precise effect of these disrupting forces, he recommends the following practical rules for their prevention:

(1) Bars forming lap joint and sustaining either tensile or compression stress should each be curved away from the other for a little less than half the lap, so that the angle of deflection of the curve and approximately the divergency between the two bars, at any distance from the point of springing of either curve, may be proportional to the difference of the stresses carried by the bars at that distance from the springing.

(2) Bars should not end pointing in the same direction as the stress (either positive or negative) carried by the concrete or contiguous bars, but approximately at right angles thereto.

(3) Bars cannot pick up stress in the same direction as, but differing in sign from, the stress carried by the concrete in which they are imbedded.

CORPS OF ENGINEERS, UNITED STATES ARMY

Professional Memoirs, vol. 6, no. 29, September-October, 1914, Washington Barracks, D. C.

Development of Explosive for Our Demolition Equipment, Major W. G. Caples

The U. S. Seagoing Suction Dredge "New Orleans," Major E. H. Schulz (abstracted)

Winter Work in the Construction and Repair of Dams and Shore Protections in the United States Improvement of the Upper Mississippi River, C. W. Durham

The U. S. Seagoing Suction Dredge "New Orleans," Major E. H. Schulz (12 pp., 4 figs., *d*). The article describes a suction hopper type of dredge with twin screws and twin rudders, built in this country. The peculiar feature of this dredge is the suction-head. This is of the Frühling type, and is at the end of the drag-arm, which is hinged and suspended from the stern of the vessel.

The dredge arm is a girder, and measures 68 ft. 6 in. between trunnion centers and dredge-head axis. It is built up of steel plates and angles attached at each end to steel castings of extra good quality. The two 26-in. steel suction pipes are built into and form part of the dredge-arm. The steel castings (trunnions) at the forward end of the arm work in steel trunnion bearings forming part of the hull in the well. To the castings at the after end of the arm are attached, first, the suction-head trunnions, and then the suction-head. Both the suction-head and suction-head trunnions were made of vanadium cast-steel. The castings at the ends of the dredge-arm are hollow and form part of the suction pipe.

The original suction-head is made of segments of three widths, and can be made 10 ft., 16 ft. 8 in., or 20 ft. wide. The pressure water (200 lb. per sq. in.) can be used as jets on the cutting edge to loosen hard material, or as mixing water inside the head when the mud is thick enough to choke up the suction to the pumps. The opening in the suction-head is controlled by portable baffle-plates.

The suction end of the arm is attached to the special hoisting winch at the stern of the dredge, by two extra pliable plough-steel cables $1\frac{1}{4}$ in. in diameter. These cables are played in and out, depending on the depth and character of material. At about the center of the dredge arm are two oak guides with steel wearing plates that work on steel rubbing plates on the sides of the well. The dredge-arm, including the suction-head, weighs about 60 tons.

The method of socket connection first used was as follows: The ends of the wire (Fig. 8A) were passed through the socket, served inside the socket with wire, the end unlaid, the heart taken out, the ends of wire bent over into the socket, and the spike driven into the heart. The ends were then brought together and pulled into the sockets with a tackle. After the end was pulled in, the socket was poured full of Magnolia white metal, and allowed to cool.

An accident occurred, however, which caused a test to be made at Tulane University, in which it was found that socket connections made exactly similar to those which broke on the dredge began breaking at loads of 44,000 and 38,200 lb., respectively, and the maximum loads carried were 53,340 and 58,090 lb.

The design of the socket has therefore been changed, and the method of connecting the cables now adopted is as follows: The cable is spliced around a thimble (Fig. 8B), making a loop, which takes the place of the eye of the socket. No data as to the strength of this construction are given.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

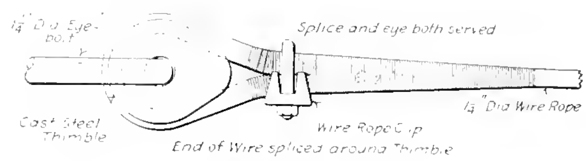
Proceedings, vol. 30, no. 4, May 1914. Pittsburg.

Measurement of the Velocity of Flowing Water, Lewis F. Moody

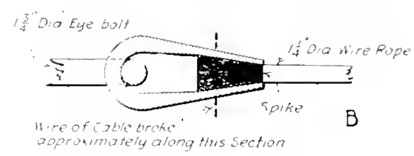
Pitot Tube Formulas—Facts and Fallacies, B. F. Groat (abstracted)

Pitot Tube Formulae, B. F. Groat (59 pp., 12 figs., *dtp*). The article discusses the application of the pitot tube formulae and possible fallacies in this connection. The author calls attention to the great difference of opinion as to whether the head raised in a pitot tube is equal to the velocity head of the impinging water or to twice that velocity head, and shows from the Bernoulli formula that the head cannot be twice the velocity head of the impinging water. He shows further that it is incorrect to claim that the effects of eddies and friction would tend to cut down the head so as to vitiate either of the resulting formulae applied in the case of the pitot tube. In the paper itself the author proves that the formula $h = \frac{v^2}{2g}$ applies to the pitot tube while the formula $h = \frac{v^2}{g}$ applies to the case of a jet impinging perpendicularly upon a plane surface. He

A



PRESENT METHOD OF ATTACHING CABLE



B

METHOD IN USE PRIOR TO BREAK OF CABLE IN SEPT 1913

Fig. 8 Two Methods of Attaching Cable in Dredges

shows also that in both of these cases, the actual maximum pressure head developed in the water is the same and is equal to $\frac{v^2}{2g}$, but the total pressure on the plane surface, if divided by the numerical value of the area of the jet, would be equivalent to an average pressure head representd by $\frac{v^2}{g}$.

An interesting part of the paper is that reporting the results of experiments by the writer, made while conducting an elaborate series of turbine tests, as well as a method of determining the coefficient of the pitot tube by a comparison of its records with the corrected records of two different types of current meter when these records are derived from the variable velocities of a tail race.

The author has found as being unqualifiably proved by experimental facts that the intensity of pressure of a jet of water upon the face of a plate is always and everywhere upon the plate less than $\frac{wv^2}{g}$, where w is the weight of a cubic unit of water, and that experiments on taking manometer pressures through holes in the plate, show that the pressure upon the surface of the plate is nowhere greater than $\frac{wv^2}{2g}$, equaling this value at the center and diminish-

ing radially therefrom in all directions. The author then proceeds to an experimental determination of the distribution of pressure from a plane surface upon which a jet of water impinges. He starts from data obtained by William Monroe White, in America, and J. S. Beresford, in India, who found that the pressure falls to a negligible value at the distance from the axis of the jet equal to the diameter of the jet and that the portion of the area of the plate which sustains any appreciable pressure is about four times the sectional area of the jet.

From the experiments of Beresford, it appears that in no case did the intensity of pressure reach that due to a column of water of a height equal to the head of water in the barrel; or in other words, to that of a head due to the velocity. In some cases it approached this limit to within 1/16 of an inch, so that had interfering causes been entirely removed, the surface of the water in the two glass tubes would have been on the same level for actual positions of the plate.

The author presents a simple mathematical proof of the pitot tube formula, which is not, however, convenient for abstracting. The conclusion to which he comes is that the change in pressure depends in no measure upon the manner in which the velocity changes from point to point, but only upon the initial and final values of the velocity, and that since the total reaction depends upon the initial and final values of the velocity and not upon the intermediate velocity gradients, the pressure head over a finite area at some point within the pitot tube is practically uniform and equal to $\frac{v^2}{2g}$.

The paper discusses to a certain extent questions of the effect of form of static opening and the reaction of a jet with respect to the static opening. The author agrees with the statements made by Mr. W. C. Rowse in his paper on Pitot Tubes for Gas Measurement in the Journal of the Am. Soc. M. E., September 1913. He discusses further the problem of the standing wave as an illustration of the operation of hydrodynamic forces as well as what he calls "natural pitot tubes."

One of the problems which the author set for himself was to determine the correctness of the indications of the pitot tube when handling very large amounts of water, e.g., such as would come from a 6000-h.p. turbine, when the observations are made in irregular currents of variable velocity. To do this, the author decided to make tests with two different types of current meter and should the meter tests not agree, to check the meters by means of a pitot tube. The meters used were a new Haskell meter of the screw type and a new large sized Price meter of the cup type, carefully rated from a boat and found to be quite reliable in the ratings when conditions were favorable. When, however, conditions were not favorable, the ratings of the two meters were found to vary quite materially; it was later determined that if the boat was rocked during the ratings, the meters would change their rates of rotation in such a way that the cup meter was always accelerated considerably while the screw meter was always retarded slightly. When the boat was rocked in about the same manner, in two ratings, one upon the screw meter and the other upon the cup meter, the deviations of the screw meter were about 1-7 those of the cup meter on the side of deficiency, the deviations of the cup meter being on the side of excess, but when the two meters were operated simultaneously in a tail race, taking the readings of equal weight, in two different comparisons, for the same meter points, the ratio of the sum of the velocities by one meter to the sum by the other meter was an almost perfect constant for the same discharge; i.e., the meters had perfectly definite ratings in the races, but these ratings were not the same as those determined from the readings in still water. Nevertheless, there was a means of estimating the true velocity of a perturbed current by means of simultaneous observation with a cup meter and a screw meter which gave a basis for determining the coefficient of the pitot tube.

The article describes and illustrates the type of pitot tube used by the author in his experiments. It has an interesting and apparently convenient supporting arrangement. In the turbine tests the dynamic orifice of the pitot tube was connected to the interior pipe while the static orifice was connected to the space between the outer casing (1-in. gas pipe) and the interior pipe (1/4-in. gas pipe). Table 2 gives a summary of the results of the comparisons of pitot tube ratings with meter ratings, representing the result of about 4000 individual readings of the head indicated by the pitot tube. It shows that the ratio of the aggregate pitot tube velocity to the aggregate Haskell velocity, by the table, is 1.004, so that on an average, the velocity of the pitot tube is greater than that of the meter. If, however, a ratio of aggregates is derived which is not affected by the variations due to differences in depth, revised figures such as are shown in Table 6 are obtained, the coefficient of the pitot tube in the last column being the ratio of the true velocity to the pitot tube velocity.

TABLE 2 SUMMARY OF PITOT TUBE AND HASKELL METER COMPARISONS FOR 99 VELOCITIES TAKEN IN DEPTHS 2, 3, 5, 6, 7 IN THE TAIL RACES

(About 4000 individual readings of the head indicated by the Pitot tube were made for the purpose of determining the figures in this table.)

Depth	No. of Expt's	Pitot	Meter	Ratio P ÷ M
2	22	76.55	72.59	1.055
3	22	82.03	81.98	1.001
5	22	86.11	86.37	0.998
6	14	59.11	60.17	0.982
7	19	80.73	82.06	0.984
Totals.	99	384.53	383.17	1.004

TABLE 3 CORRECTED PITOT TUBE AND HASKELL METER COMPARISONS

(Compiled from Tables 2 and 5)

Depth	True Velocity Table No. 2	Velocity by Haskell Table No. 2	Ratio of Vel by P to Vel. by H Table No. 5	Computed Velocity by Pitot	Coefficient of Pitot Tube
2	3.98	3.90	1.055	4.11	0.968
3	4.48	4.44	1.001	4.44	1.010
5	4.92	4.89	0.998	4.88	1.009
6	5.57	5.55	0.982	5.45	1.021
7	6.17	6.15	0.984	6.05	1.020
	25.12	24.93		24.93	1.008

Mean coefficient of Pitot tube in tail races = 25.12 ÷ 24.93 = 1.008.

In closing, the author describes a boat rigging which may be conveniently employed on large rapid streams of considerable depth where it is intended to determine the discharge by means of a pitot tube or current meter. In an appendix the author explains the principles of a chemical method of measuring the discharge of water by means of introducing into the water upstream a certain reagent and bringing it, in the water, downstream. He explains the precautions which have to be taken and the general method of carrying out the analysis and estimation. A bibliography of the measurements of air, gas and water flow by means of a pitot tube is given.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Transactions, vol. 30, part 4, August 1914, Newcastle-upon-Tyne.

High-Speed Bearings, Gerald Stoney (14 pp., 13 figs. and 3 plates, *dg*). The article gives a brief historical sketch of the theory of friction and lubrication as applied to high-speed bearings as well as the marine situation in this field of engineering. Among other things, the author gives fairly complete data of the experiments on high-speed bearings, made by O. Lasche, which are of particular interest because the number of *Traction and Transmission* (vol. 6, numeral 22, 1903) in which they were published, is now out of print. His tests show that so far as friction is concerned, it is not well to use a large shaft and a long bearing, which, however, have to be used for high speeds and heavy loads in order to avoid vibration, critical speeds and fractures due to vibrations. If the pressure is not too high nor the oil too thin, a bearing may run all right so long as there is no vibration, but if vibration occurs, the oil film may be driven out and seizing take place. Besides, in all high-speed bearings, artificial means have to be used to carry off the heat, the radiation from the bearings not being sufficient. This is important, since from Lasche's experiments it was found that the friction is practically inversely proportional to the temperature measured from freezing point, but after a certain temperature, it directly increases and seizing takes place, due to the loss of viscosity. Water jacketing the bearings has not been found as satisfactory as the plan of supplying sufficient oil to carry off the heat and oil coolers are preferable (to cool the oil) as well as oil circulation around the outside of the bearings. The heat to be removed is not only that caused by friction, but also that caused by conduction from the steam. The heat which has to be carried off by the oil may be expressed as

$$\text{B.t.u.} = Kdlv$$

where d is the diameter of the bearing in inches, l the length of the bearing in inches, and v the surface velocity in feet per second, the constant K varying inversely as the temperature above freezing point.

In marine practice, the formula B.t.u. $= dlv^{1.38}$ is used and gives slightly greater results for the usual speeds in marine work and an oil temperature of about 100 deg. fahr. Thrust bearings in land turbines which are perfectly balanced, are working with very low pressures, never exceeding 20 lb. per sq. in. and even in marine turbines, 50 lb. per sq. in. is never exceeded. There are no tests available as to the friction of such bearings, but it is probably fairly high, as perfect lubrication is difficult to obtain and as, in addition to the area of the main bearings, the area of the top and bottom halves of the collar have to be added in estimating the quantity of oil required and the surface of the oil cooler. Owing to the low pressures employed, such bearings have usually a high coefficient of friction as the lubrication is rarely perfect on account of the general operation being different from that of journal bearings and no wedging action taking place and admitting oil. The author proceeds to describe the investigation of Osborne Reynolds and Michell which led the latter to devise his well-known thrust bearing with segmental blocks pivoted at the theoretical center of pressure.

In the discussion which follows, Mr. Newbigin calls attention to the effect of the slipper shaped blocks in the pivoted thrust bearing and stated that the friction increases rapidly when the length in the direction of rubbing is more than the radial dimension of the block. Better results were obtained when the blocks were pivoted at or near the theoretical center of pressure in the oil film than when pivoted in the center of their area. The latter method of pivoting is not mechanically simpler since bearings with the blocks pivoted behind their center of area for both directions of rotation have been made for the last three or four years without mechanical complications.

With respect to the effect of pivoting the blocks incorrectly, the following results of tests were given:

TESTS ON MICHELL THRUST BEARINGS MADE AT MESSRS. BELLIS & MORCOM'S WORKS, BIRMINGHAM, JUNE 8 AND 9, 1910

There were three blocks in the bearing, each having a surface of 1 sq. in. The cross dimensions of the blocks were equal.

The temperature was taken by means of a thermometer placed in a hole drilled in one of the blocks.

Speed 1750 r.p.m., or 28.67 ft. per second
Absolute viscosity of the oil at 126 deg. fahr., 4.6
Pressure on the blocks, 500 lb. per sq. in.

Position of Pivoting Point	Temperature of Bearing. Deg. Fahr.
1/16 in. in front of center	135
Central	132
1/16 in. behind center	126
1/8 in. behind center	124

Increase in friction for blocks centrally pivoted, 15 per cent

TESTS MADE BY MR. MICHELL IN MELBOURNE, SEPT. 2 TO 15, 1913

Diameter of Thrust Collar, 6 in.
Number of Blocks, 2
Area of bearing surface of each block, 4.5 sq. in.
Total load on blocks, 5000 lb.
Mean intensity of pressure, 555 lb. per sq. in.
Pivot 1/8 in. behind center of bearing surface with clockwise rotation
Pivot 1/8 in. in front of center of bearing surface with counter-clockwise rotation

TESTS MADE BY MR. NEWBIGIN

Mean radius of action, 0.16 ft.
Oil-Mineral, C.G.S., viscosity 0.1 at 60 deg. fahr.
Bearing air-cooled, radiating surface, about 2 sq. ft.
Bearing driven by small D. C. motor at an average speed of 1356 r.p.m.
B.h.p. required to drive the bearing under load, 0.372
Equivalent coefficient of friction, 0.0018

Duration of Test	Temperature of oil in bearing above that of the atmosphere at end of test
Bearing running forwards—	
10 runs of 9 hours each	Average 85 deg. fahr.
Bearing running backwards—	
1 run of 8 hours	100 deg. fahr.

The blocks were weighed before and after a fortnight's run, and the loss was too small to be detected, being less than 2 grains.

Increase in friction for blocks running backwards, $16\frac{1}{2}$ per cent.

Assuming the viscosity of the oil at working temperature to be 0.025 absolute, the coefficient of friction by Michell's formula would be 0.001025, as against 0.0018 by experiment.

Mr. Cook had the opportunity of conducting some experiments with pivoted segmental blocks for thrust bearings, and found the resistance of such thrust blocks and the ease with which they sustained high pressures to be very great.

The theory of lubricating films developed by Prof. Osborne Reynolds was not perfect in the estimation of the theory as it neglected the effects of temperature and capillary action, which latter might be considerable for thin films.

The following information on the design of oil coolers was presented during the discussion by M. G. S. Swallow and E. E. Williams.

The ordinary oil cooler was made like a condenser with the water circulating outside and the oil inside the tubes, the velocity of the oil through the tubes being about 2 ft. per second. Such a cooler with ordinary $\frac{5}{8}$-in. condenser tubes and with cooling water at 65 to 60 deg. fahr., would cool oil from 115 to 100 deg. fahr., at the rate of about 2 cu. ft. of oil per sq. ft. of cooling surface. With smaller tubes $\frac{1}{2}$ in. outside diameter about $3\frac{1}{2}$ cu. ft. could be cooled, or about $4\frac{1}{2}$ cu. ft. from 140 to 125 deg. fahr., but the pressure drop over the cooler was considerably increased. In some cases retarders had been used in the tubes or the tubes flattened at intervals like a Royles tube so as to increase the cooling effect by mixing the oil, but such devices increased the pressure drop very much, and were, in his opinion, of doubtful value.

The amount of cooling water might be about one-third of the volume of the oil, giving a rise of temperature in the cooling water about equal to the drop of temperature in the oil. A form of oil cooler which had been used very successfully on the Continent was one like an ordinary condenser with the water inside the tubes and the oil outside. By suitable baffles the oil was caused to pass several times at right angles to the tubes, and in passing through the tortuous spaces between them the oil became very thoroughly mixed up, and so the cooling was very complete. In such coolers it was stated that as much as 10 cu. ft. of oil could be cooled per sq. ft. cooling surface. The great advantage of such a cooler was not so much that it enabled a smaller cooler to be used, but that with a cooler of the same size as at present a better cooling effect could be obtained and the oil maintained at the lower temperature at which it retained its lubrication quality for a longer period.

A fair figure to take for fixing up the surface of an oil cooler for such conditions, i.e., 70 lb. pressure per sq. in. at a velocity of 30 ft. per second and a rise of temperature of 20 deg. fahr., was 200 lb. of oil per sq. ft. of cooling surface. The class of oil used on these examples was of a good standard as would be seen from the following comparison:

Standard	Oil Used
Flash point, 400 to 410 deg. fahr	406 deg. fahr.
Specific gravity, 0.875 to 0.880	0.8755
Viscosity at 180 deg., 73, 77 sec.	....
Viscosity at 140 deg.	155 sec.
Viscosity at 120 deg., 210 225 sec.	228 sec.
Viscosity at 100 deg.	395 sec.
Viscosity at 80 deg.	670 sec.
Viscosity at 70 deg., 930 960	.....

If a curve be plotted for comparison it would be seen that the oil used was up to the standard for flash point, specific gravity and viscosity. This oil was tested for viscosity after it had been subject to changes of temperature and it was observed that the oil did not quite reach the standard, as the flash point became 430 deg. fahr. sp. gr. 0.8790.

Viscosity 104 deg. at 400 sec.
112 deg. at 318 sec.
123 deg. at 232 sec.

A sample of the oil was submitted to a temperature of 150 deg. fahr. and it was found to have lost 54 per cent in weight, but no carbonization was observed at this temperature and practically no change of color. A further test was made and carbon was seen to form at 160 deg. fahr. Experience had been gained with bearings running at 160 deg. fahr. and it would appear from the state of the bearings after examination that the oil showed a tendency to carbonize at this temperature, which proved that a temperature of 150 deg. fahr. should not be exceeded.

SOUTH AFRICAN INSTITUTION OF ENGINEERS

Journal, vol. 12, no. 11, June 1914, Johannesburg.

The Principle of Similarity and its Application in Machine Design (16 pp., 9 fig. *t*). The author proposes to show the adaptation of the principle of similarity to machine design. He claims that while exact similarity in machine design cannot be advocated in many cases, designers would be much less in error and would realize higher commercial economy by similarity entirely rather than varying proportions from little machines to large machines in the unscientific manner which he believes is so obvious in their design. The principle of similarity may be roughly expressed by saying that theoretical designs of all the machines of a series of engines of graduating power can be similar if similar conditions of working are assumed for all. The author proceeds to show what are the similar conditions of use, and how similarity applies to the case of roller-bearing, what the relation is between similarity and centrifugal whirling, and what fluctuation of velocity is permissible by fly-wheels of similar form in similar engines, as well as what are the fractional variations of speed allowed by similar governors in similar engines. He considers further the question of power and weight of similar engines working under similar conditions, that is, constant linear speed and constant head of pressure. From this he passes to a brief discussion of similarity in automobile engines and steam turbines as well as to the relation of linear speed to economy of material, and the effect of reduced linear speeds, occurring in small engines on similarity of fly-wheels. The author uses mathematical methods sparingly and presents a clear account of this rather imperfectly known subject.

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

PERSONALS

William C. Adams, formerly associated with the Chase Metal Works, Waterbury, Conn., as engineer, has accepted the position of assistant superintendent of the Detroit Copper and Brass Rolling Mills Company, Detroit, Mich.

W. N. Dickinson has become associated with the General Elevator Company of New York. He was until recently manager of the foreign department of the Otis Elevator Company, New York, prior to which he was temporarily in charge of their Chicago works and Middle West construction, and later had charge of their engineering on the Pacific Coast.

R. C. Hargreaves has accepted the position of traffic engineer of the Federal Motor Truck Company, Detroit, Mich.

Fred B. Corey, formerly for eleven years in the engineering department of the General Electric Company, and for the past three years engineer of inspection and tests of the Union Switch and Signal Company, has resigned that position and opened an office in the Arrott Building, Pittsburgh, Pa. He will conduct a consulting engineering business, making a specialty of inspection methods and organizations for manufacturing companies, and will also give attention to electric railway signalling and allied subjects.

A. F. Barnes, formerly with the engineering departments of the University of Pennsylvania and Middlebury College, has been appointed dean of engineering of New Mexico State College, State College, New Mexico.

M. I. Nusim is now connected with the turbine department of the Westinghouse Machine Company, East Pittsburgh, Pa. He was until recently identified with the turbine engineering department of the General Electric Company, Lynn, Mass.

Charles A. Waring has severed his connections with the National Cash Register Company, Dayton, Ohio, as draftsman of the electric engineering department, and is now associated with the engineering department of the Reo Motor Car Company of Lansing, Mich.

Arthur R. Jealous, formerly associated with the General Electric Company, Boston, Mass., has accepted the position of assistant superintendent of works of the Clark Thread Company and Clark Mile End Spool Cotton Company, Newark, N. J.

Sverre Petersen has become affiliated with the Southern Well Works Company, Chattanooga, Tenn., as chief engineer. He was until recently connected with the Henry R. Worthington Company, Harrison, N. J., in the capacity of mechanical engineer.

P. C. Philipp, for many years on the staff of the American Appraisal Company and of late in charge of the valuation department for Day & Zimmerman, Philadelphia, has opened an office of his own in Philadelphia. He will specialize on valuation of public utilities exclusively. Mr. Philipp has been retained by a number of Ohio companies to make a valuation of their properties.

A. L. Breckenridge has severed his connection with the Narragansett Electric Lighting Company, Providence, R. I., as building inspector, and is now employed as a draftsman by the Pennsylvania Steel Company, Steelton, Pa.

Eilert Nesdahl, formerly in the employ of the Buffalo Forge Company, Buffalo, N. Y., has accepted a position with Warren Webster & Company, Camden, N. J.

Edward J. Kunze, who for the past four years has been assistant professor of mechanical engineering in charge of machine design and construction at the Michigan Agricultural College, East Lansing, Mich., has been appointed professor of mechanical engineering in charge of the department of mechanical engineering at the Oklahoma Agricultural and Mechanical College, Stillwater, Okla.

EMPLOYMENT BULLETIN

Note: In sending applications stamps should be enclosed for forwarding.

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

POSITIONS AVAILABLE

809 Designers with experience on either hull or engine work; also designers on marine steam boilers and piping. Salary four to six dollars per day. Location Baltimore, Maryland.

810 Engineer thoroughly experienced in design and operation of modern oil engines. Location Illinois.

811 Manufacturing superintendent on gas engine work; must be thoroughly experienced in modern methods, and possess tact and energy. Excellent opportunity in broad line for man with ability.

900 Energetic, ambitious young man to sell power plant equipment. Technical graduate preferred. Experience as salesman not essential, but preferred. Excellent opportunity for right man. Location Pittsburgh. Apply through Society.

901 Instructor in experimental engineering; prefer one several years out of college with both practical and teaching experience. Salary \$1100 to \$1200. Location Pennsylvania.

902 Chief draftsman for turbine department of forty to fifty men; preference given to one familiar with large steam apparatus and capable of handling design of large machines and a good disciplinarian. Apply through Society.

903 Experienced graduate, mechanical and electrical engineer, familiar with problems incidental to the construction, improvement and maintenance of iron and steel works. State experience and salary desired, also references as to ability and character. Apply through Society.

904 Assistant to chief engineer of sugar factory; must have knowledge of electrical machinery and practical experience. Location Porto Rico. Salary \$125 per month with board.

909 Several men to represent Michigan concern in exclusive territories. Positions call for a thorough knowledge of boiler equipment and selling experience. Apply through Society.

910 Draftsman, if possible one with knowledge of agricultural implements. Location Massachusetts. Salary according to ability, probably one hundred dollars a month to start. Position permanent and good opportunity for advancement. Apply by number through the Society.

912 Engineer to take entire charge of factory in New York, manufacturing portable metal furniture. Apply through the Society.

MEN AVAILABLE

J-1000 Junior, graduate mechanical engineer, four years experience in office, testing and sales for company manufacturing pumps and air compressors, one year editorial work with magazine devoted to internal combustion engines, desires position in commercial line, preferably sales. At present employed.

J-1001 Member, M.I.T. graduate, age 36, wide experience in manufacture of machinery and exporting, desires to act as manufacturer's export representative in New York.

J-1002 Student member, Stevens 1914 graduate, desires position with contracting concern or consulting engineer. Location immaterial.

J-1003 Member, technical graduate, age 32, experience as machinist, shipping clerk, draftsman, master mechanic, mechanical engineer, assistant superintendent and superintendent, competent to take position as general manager of plant employing several hundred men. Location New York preferred.

J-1004 Superintendent, age 39, broad experience in designing tools and labor saving devices for increasing production in interchangeable manufacturing work. Expert in punch press work and construction of dies for sheet metal stamping and forming. Has had complete charge of plant. Location preferred in the East.

J-1005 Mechanical graduate, age 30, three years experience technical advertising, six years engineering instructor, well versed in theory and practice. Salary $3000.

J-1006 Mechanical engineer, technical graduate with successful selling experience, contemplates opening office in Chicago. Would like to hear from manufacturers desirous of having their product marketed in Chicago and surrounding territory.

J-1007 Young engineer, technical graduate, has had experience in repair work of locomotives and charge of several important tests, desires to locate near New York. At present employed.

J-1008 Member, graduate Stevens Institute of Technology, age 33, energetic and reliable, successful executive, four years experience as chief draftsman, two years as production superintendent, and two years as mechanical superintendent, desires position as factory manager or general superintendent. At present employed.

J-1009 Junior, M.I.T. graduate, journeyman machinist, experienced in design, inspecting, research, steam power, repair work and correspondence, desires position with consulting engineers or manufacturing concern, preferably in the South. At present employed.

J-1010 Associate-Member, age 28, desires an opportunity, with possibilities for advancement. Specialty steam turbines and steam power plant equipment. Will sacrifice salary for real opportunity. At present employed.

J-1011 Member with broad shop experience in medium and heavy work desires to connect with progressive concern requiring the services of a capable superintendent.

J-1012 Technical graduate, mechanical engineer, Stevens '03, ten years experience in drafting and engineering work, also manufacture of water gas and soap. Five years with large anthracite coal operating company in eastern Pennsylvania in design, erection and maintenance of machinery for handling and dressing coal.

J-1013 Member, technical graduate, age 35, married, 15 years experience designing, erecting and operating high grade steam power plants. Special attention given to improvements in plants and fuel economy, thoroughly familiar with handling California crude oil as fuel. Location preferred California or some other part of the West.

J-1014 Major interest will be assigned in foreign patents in consideration for putting new device on the U. S. market, or for providing means to do so. The device is applicable to machinery in general, including automobiles, and has been thoroughly tried out in practice. U. S. patents were recently granted.

J-1015 Member, mechanical and electrical engineer, technical graduate, Assoc. A.I.E.E., 15 years practical experience, 12 years in executive positions as chief electrician, power plant chief engineer, mechanical engineer and master mechanic, successful in handling men, thoroughly familiar in engineering correspondence, compiling plant reports, commercial testing, etc. desires position with large mining and smelting companies. At present employed. Location immaterial, but prefer South or West.

J-1016 Junior, graduate M.I.T., age 29, married, five and one half years experience in design and construction of power plants, desires executive position, assistant to superintendent, or manager with company with good chance for advancement. At present holding responsible position.

J-1017 Associate-Member, graduate mechanical engineer, thoroughly familiar with designing and testing of air compressors, blowing engines, vacuum pumps using plate valves and large steam engines (drop valve gear), also commercial experience, desires responsible position. Knowledge of French and German.

J-1018 Junior, age 26, married, eight years shop and drafting room experience on small and medium size machinery. Steady, industrious worker, systematic, accurate at figures and good correspondent, desires position in shop or office. Location immaterial but prefer New England or New York. Salary $100 per month.

J-1019 Mechanical engineer with eleven years experience as engineer and superintendent in varied manufacturing lines open for engagement November first.

J-1020 Mechanical engineer, technical graduate, ten years experience automatic machinery and experimental work, desires executive position with chance for advancement. At present employed.

J-1021 Junior, Stevens graduate, age 30, capable executive in new and re-construction and equipment of mills and factories; designer along electrical and steam power lines, structural and reinforced concrete architecture, desires an engagement. At present chief engineer for metropolitan firm of industrial engineers now completing new manufacturing plant in South.

J-1022 Member, technical graduate, with commercial training, speaking five languages, fully conversant with Latin and South American trade conditions, 18 years varied experience in design and construction of machinery and buildings, remodeling, maintenance and operation of industrial plants and equipment; systematizing of shops and processes along scientific management lines, testing and general plant engineering; familiar with handling men, drawing up contracts, purchasing equipment and material, appraising properties, modern methods of manufacturing and marketing products, desires to become identified with manufacturing or industrial plant in responsible administrative or executive position. At present employed.

J-1023 Manufacturing superintendent or shop manager, good organizer and executive, familiar with modern and economical manufacturing methods including the premium and bonus systems and time study. Successful in increasing production and reducing costs without adding new equipment; thorough knowledge of the value and efficiency of the latest improved manufacturing machines.

J-1024 Graduate mechanical engineer, age 28, married, 12 years experience in shop, drafting and design of European Diesel oil engines, automatic machinery and industrial plants, desires position as mechanical engineer, or assistant to superintendent of industrial firm. At present employed.

J-1025 Member, 25 years experience in design and construction of machinery, building crushing plants, power plant work and mill engineering, also familiar with purchasing of materials and equipment, desires to be identified with manufacturing or industrial plant in responsible position.

J-1026 Junior, Columbia University graduate, one year practical experience designing and testing air machinery, power plants and industrial processes to discover losses and determine costs of production, desires position as assistant

to manager or superintendent of industrial concern. Location immaterial.

J-1027 Cornell graduate, age 28, married, six years experience at blast furnace, steam specialties and motor cars; four years high class motor trucks and carriages, one year in charge small factory office, wishes opportunity in executive line. Location and travel immaterial.

J-1028 Member now located on the Pacific coast, for many years connected with a large steel company in this country, desires to establish an agency representing a number of reputable Eastern manufacturers.

J-1029 Mechanical engineer, technical graduate, age 30, knowledge of Spanish-American business, sugar plantation work and sales engineer, thorough knowledge of gasolene, oil and steam engines, all types of pumps and pumping machinery and sugar house machinery.

J-1030 Mechanical and electrical engineer, technical graduate, 14 years experience in design, operation and appraisal, broad knowledge of several branches of engineering and keen insight particularly fit for investigations and reports, desires permanent position in or near New York.

J-1031 Member, graduate M.E., with experience in export of hydraulic and pneumatic machinery, also internal combustion motors, associated with old established importing and exporting house in New York, open for export agency; lines of small foolproof machinery, special tools, valves, alloys, etc., preferred.

J-1032 Member, technical graduate, desires position as mechanical engineer or assistant to superintendent or manager; experienced as chief draftsman in manufacturing lines.

J-1033 Graduate engineer, age 32, single, technical knowledge mechanical and electrical engineering, 12 years practical experience design, construction and operation of steam power plants, hydroelectric plants and sub-stations, piping layouts, etc., desires position with consulting engineer or large contracting firm. Salary $175. Location New York or vicinity.

J-1034 Mechanical engineer with offices in London, England, who has successfully introduced various railway specialties of American manufacturers in Europe, is open to negotiate with prominent manufacturers of railway rolling stock and specialties with a view to establishing and extending their export business in Great Britain and its colonies. Highest references.

J-1035 M. I. T. graduate in mechanical engineering, post graduate course in electrical engineering, twenty years experience in design and construction of machinery, and buildings, manufacturing, systematizing and accounting, desires permanent position.

J-1036 Junior, Stevens graduate, age 30, varied experience in office of consulting engineer, complete charge of work and considerable responsibility; experience in reports, designs and appraisals of numerous industrial and power plants and municipal works. Best references.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

Aeronautical Society of America. Constitution, by-laws list of members, etc., *1914. New York, 1914.* Gift of C. W. Rice.

Asphalts, their Sources and Utilizations. T. Hugh Boorman. 1914 road edition. *New York, 1914.* Gift of author.

This is the second edition of the work. It treats of the origin and uses of asphalt especially in road construction, and is profusely illustrated with full page plates of existing roads. W. P. C.

Association of Railway Telegraph Superintendents. Proceedings of Annual Meeting, 1914. *Milwaukee, 1914.* Gift of association.

Association of Transportation and Car Accounting Officers. Proceedings, June 1914. Gift of association.

Cement Mills Electric Drive, an Analysis of Its Benefits. T. H. Arnold. *Philadelphia.*

Cotton Combing Machines. T. Thornley. *London, 1902.*

Gear Cutting in Theory and Practice. J. G. Horner. *Manchester, 1914.*

Illinois Water Supply Association. Proceedings of 5th Meeting, 1913. *Urbana, 1913.*

Institution of Civil Engineers of Ireland. Index to Transactions, 1845-1910. *Dublin, 1911.* Gift of G. E. Stechert & Co.

Instructions for Making Improvement Thinnings and the Management of Moth-infested Woodlands. H. O. Cook and P. D. Kneeland. *Boston, 1914.* Gift of Mass. State Forester.

Iron Ores, Their Occurrences, Valuation and Control. Edwin C. Eckel. *New York,* McGraw Hill Book Co., 1914. Gift of publishers.

Treats of the abundance and wide distribution of iron, and the genesis of iron ore deposits; of the factors affecting the value of iron and the valuation of deposits; on prospecting, mining costs, mill costs as affecting valuation. Then follows a detailed description of the more important ore deposits of the world, with full references to the literature. The final chapters are devoted to an economic study of iron ore resources as affecting the future development of the iron industry, special attention being given to the conditions affecting the American iron industry. W. P. C.

Kansas Engineering Society. Transactions and Report of the 6th Annual Meeting, 1914. *Topeka, 1914.* Gift of society.

Los Angeles (Cal.) Department of Public Utilities. 4th Annual Report of the Board. 1912-1913. *Los Angeles.* Gift of Department of Public Utilities.

Melbourne University Calendar, 1913. *Melbourne, 1912.* Gift of A.S.M.E.

New York State Conservation Commission. 2d Annual Report, 1912. *Albany, 1913.* Gift of Commission.

New York State Engineer & Surveyor. Annual Report, vol. 1, 1913. *Albany, 1914.* Gift of New York State Engineer and Surveyor.

Recent Supreme Court Decisions on Engineering Contracts and Liabilities of Sureties upon such Contracts. G. A. King.

La Soudure Autogène. *Paris.*

Springfield (Mass.) Water Commissioners. 40th Annual Report, 1913. *Springfield, 1914.* Gift of Board of Water Commissioners.

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Uber die Theorie des Kreisels. F. Klein and A. Sommerfeld. pt. 2-4. *Leipzig, 1898, 1903, 1910.*

Uhland's Handbuch für den praktischen Maschinenkonstrukteur. vols. 1-4, 6-13. ed. 2. *Berlin.*

University of Minnesota. College of Engineering. 1914-15. *Minneapolis, 1914.* Gift of University.

Die unmittelbare Umsteuerung der Verbrennunskraftmaschinen. Ch. Pöhlmann. *Berlin, 1914.*

Vereines deutscher Ingenieure. Inhaltsverzeichnis der Zeitschrift. 1877-1883, 1884-1893. *Berlin, 1884, 1895.*

Verein deutscher Ingenieure und Seine Arbeiten, Description of. *Berlin, 1914.* Gift of the Verein.

Gift of William J. Hammer

Aeronautical Society. Official Program, Aviation Decennial Celebration, 1903-1913.

Better Business, Wm. Hard.

Chronology of Aviation, H. Maxim and W. J. Hammer.

Historical Collection of Incandescent Electric Lamps.

Youthful Franklin. An Oration Delivered at the Unveiling of a Statue of Benjamin Franklin in 1723 at the University of Pennsylvania, June 16, 1913, Jas. M. Beck.

Gift of National Commercial Gas Association

Gas Equipment of the Home. *New York, 1914.*

Hygienic Value of Gas Lighting, R. F. Pierce.

Proposed Gas Fixture Specifications as Recommended by the Committee on Standardization of Gas Appliance Specifications. 1913.

Proposed Gas Range Specifications as Recommended by the Committee on Standardization of Gas Appliance Specifications. 1912.

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Electric Weighing Co., *New York, N. Y.* Bull. no. 8. Messiter conveyor scales, 15 pp.

Ferro Machine & Foundry Co., *Cleveland, O.* Ferro rowboat motor, 16 pp.

Flannery Bolt Co., *Pittsburgh, Pa.* Staybolts, July 1914.

Gardner Machine Co., *Beloit, Wis.* Gardner Grinder, May-June 1914.

Gas Machinery Co., *Cleveland, O.* Form 390. New coal gas plant of Porto Rico Gas Co., San Juan, Porto Rico, 16 pp.

Leschen, A., & Sons Rope Co., *St. Louis, Mo.* Leschen's Hercules, July 1914.

Lunkenheimer Co., *Cincinnati, O.* Lunkenheimer whistles, 23 pp.

North Western Expanded Metal Co., *Chicago, Ill.* Expanded metal construction, July 1914.

Stephens-Adamson Mfg. Co., *Aurora, Ill.* Labor saver, no. 64.

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Yale & Towne Mfg. Co., *New York, N. Y.* Yale Hoisting Hints, July 1914.

UNITED ENGINEERING SOCIETY

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Gesamt-Zeitschriften Verzeichnis. *Berlin, 1914.*

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Prevention of Dampness in Buildings, Adolf W. Keim. *London, 1902.*

Psychology of Management, L. M. Gilbreth. *New York, Sturgis & Walton Co., 1914.*

A publication in book form of the essays appearing originally in *Industrial Engineering.* A careful study of the underlying principles of scientific management. W. P. C.

Recent Cotton Mill Construction and Engineering, Joseph and Frank Nasmith. Ed. 3. *Manchester, 1909.*

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Chicago Pneumatic Tool Co., Chicago, Ill. Ideal Power, July, 1914.

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Sherwood Mfg. Co., Buffalo, N. Y. The "Hart" oil pump.

Texas Co., New York, N. Y. Lubrication, July, 1914.

Under-Feed Stoker Co. of America. Publicity magazine, August, 1914.

Walworth Mfg. Co., Boston, Mass. Model Piping Specifications, a Guide for Engineers. Copies can be had by addressing Power Dept., Walworth Log, Sept., 1914.

Winslow Safety High Pressure Boiler Co., Chicago, Ill. Winslow Safety High Pressure Boiler, 53 pp.

Yarnall-Waring Co., Philadelphia, Pa. Log book of the power plant, 88 pp.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1914, and in the January and July 1914 issues of The Journal

Buyer's Notes

FIGURE

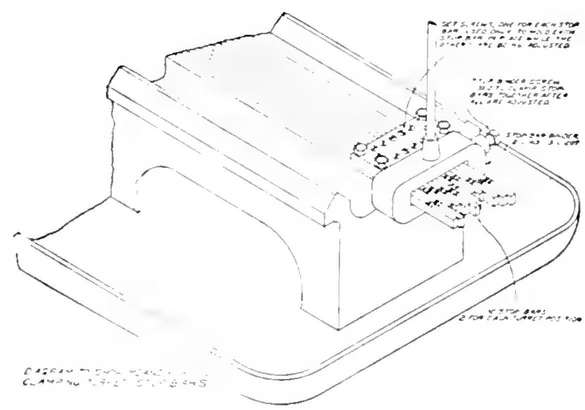


FIGURE 2

Nothing, perhaps, is more interesting to the buyer or the man held responsible for the purchase of a machine, than condensed facts which will enable him to ascertain the superior features of the machine in question. These facts, of course, must relate to the design and construction of the mechanism, both in part and as a whole.

On pages 2 and 3 of the Journal of the A. S. M. E., Sept. issue, we described the mechanism for revolving the turret; on these pages we will describe the unique turret stop mechanism used exclusively on Jones & Lamson Turret Lathes. It is not necessary to be a trained mechanic to appreciate the value of the simple mechanical principle nor is it a matter of conjecture as to the stability of this stop mechanism—every detail is simple and strong, and hardened where surfaces are subjected to hard usage, insuring absolute accuracy at all times. It eliminates that feeling of uncertainty when your work demands absolute accuracy on every piece, regardless of quantity or rough handling of an inexperienced operator.

The precision with which a machine controls the dimensions of the work is one of the principal points by which it is judged, and accurate duplication is utterly impossible without efficient stop mechanism.

12—Stop bars
12—Stop bolts
6—Lifting cranks
6—Tappet rods
6—Turret positions
6—Concaved notches
1—Lifting handle with six fingers
1—Interchangeable auxiliary stop bolt

Note carefully their functions described on the next page, the simple mechanical principle, simplicity of parts and strength of parts, then compare this mechanism with other makes of turret lathes and you will clearly understand why the Jones & Lamson turret lathes are most efficient from every conceivable point. That's the intelligent way to pass on a turret lathe.

Seven stops for any one position of the turret or Two Stops for each turret position if all positions are used. These stops may range from 1 to 7 on any desired position; five of them are obtained by means of the "Auxiliary Stop Bolt."

Fig. 2 is a continuation of the drawing, Fig. 1, showing the **ends** of the **stop bars A-1, B-1, A-2,** etc. The **binding screw attachment** is also shown on Fig. 2.

Accurate Duplication Requires Accurate Stops

There are **twelve "stop bars,"** see drawings for names, **twelve stop "bolts," six "tappet rods"** and **six "lifting cranks"; one "lifting crank"** and **one "tappet rod"** for **each pair** of **"stop bolts."**

When a machine is set up, **each "stop bar"** is adjusted to the desired stopping point. As the turret carriage moves forward the lower surface of the **"stop bolt"** rides on the **"stop bar,"** used for that position of the **turret,** until it reaches the **notched end** of the **bar,** then it slides down the beveled surface and after a short travel it reaches the **abutment** at the end of the bar. This **abutment** acts as a **positive stop** and instead of the release and rebound action peculiar to other types of stop mechanism, the **friction feed** described on *Pages 2 and 3 of the Journal of the A. S. M. E. August issue,* holds the carriage rigidly against the **abutment,** effecting an accurate shoulder on the work.

In revolving the turret there are **six stopping positions,** any or all of which may be used at the operator's option, and **in each position** there is a **concaved notch** milled on the periphery of the turret, opposite the **"lifting crank"** which actuates the **two "stop bolts"** for that position.

In Fig. 1, the **"A-1" "stop bar"** is being used and the **concaved notch** is shown in dotted lines **opposite** the **"tappet pin."** The **"A-1" "stop bolt"** is also shown in a **locked position** in the notch of **"A-1" "stop bar."**

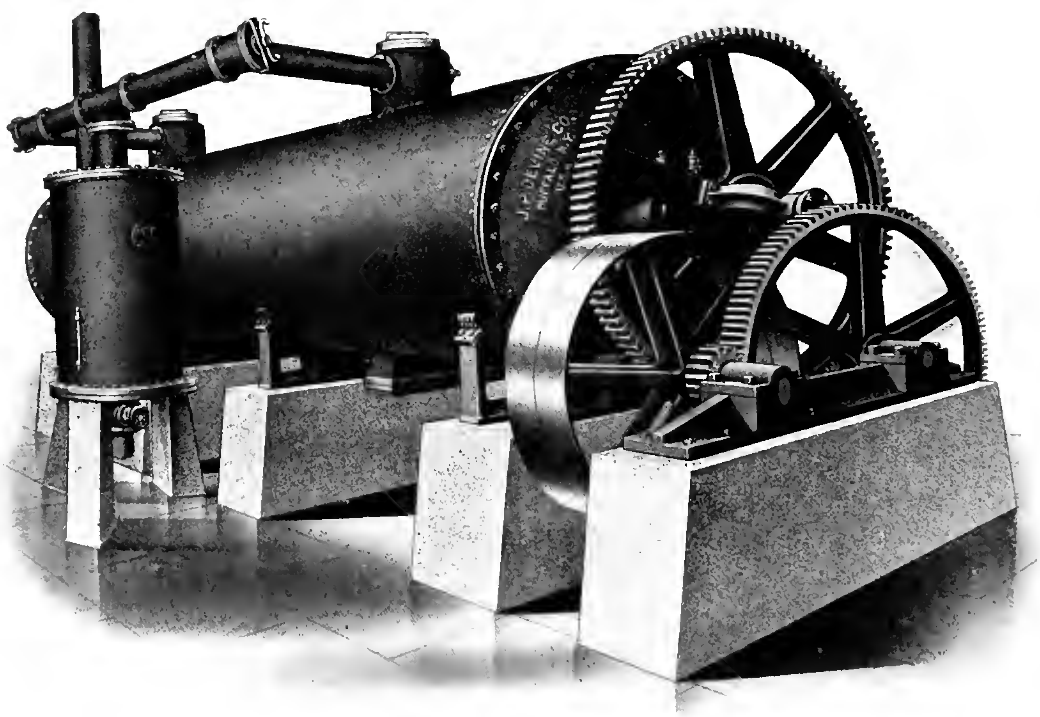
The **concaved notches** on the turret, face upward and downward, alternately, to accommodate their respective **"tappet pins."** These **notches** serve as a **release** for the **"tappet rods"** and **"stop bolts,"** permitting the **"tappet pin"** to move forward as the **"stop bolt" drops into** the **notch** in the **"stop bar."**

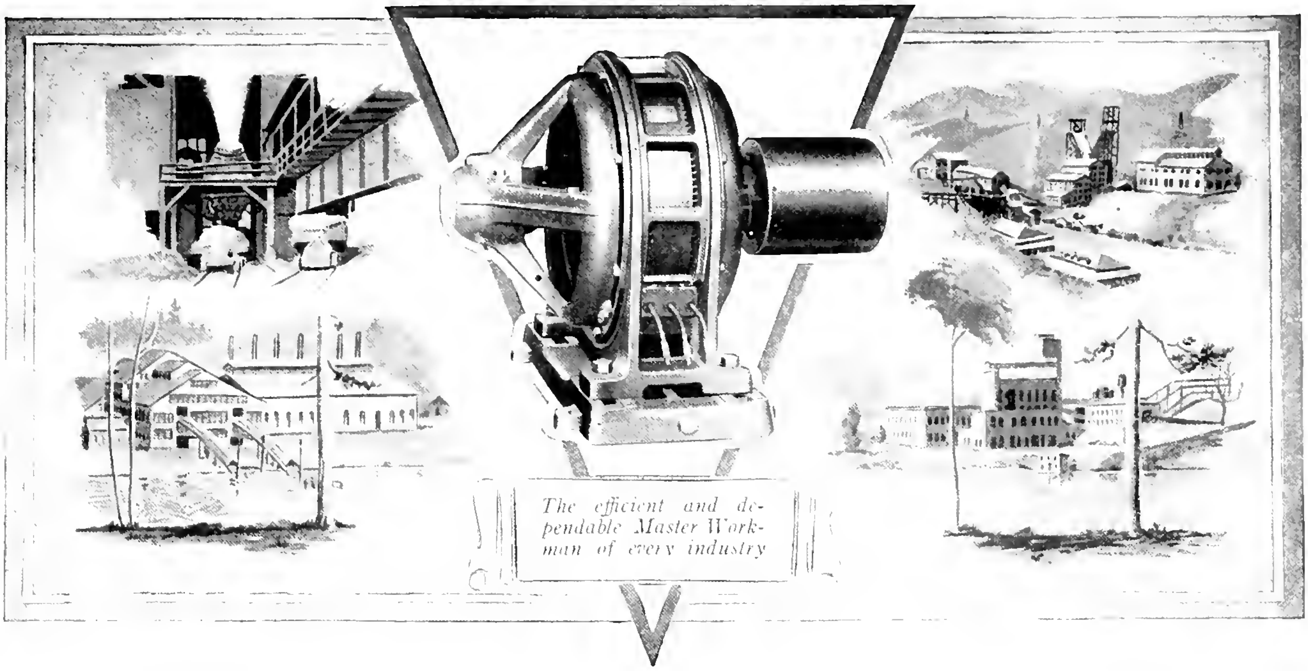
The **"tappet pins"** ride on the periphery of the turret and press against the **oscillating "lifting crank"** which in turn, holds the **"stop bolts"** up, preventing them from engaging with the **notches** of the **"stop bars"** until the **proper position** of the **turret** and **proper notch** is brought directly opposite the **proper "tappet pin."** There being **twelve stop bars** and only **six positions** of the turret, **two stops**—one A and one B are obtainable for each position of the turret.

Each **"stop bar"** has its individual **"stop bolt"** and there is but **one "lifting crank"** and **one "tappet pin"** for **each pair** of **"stop bolts,"** therefore, if **two stops** are required with **one position** of the **turret,** after the **"A-1 stop bolt"** has reached its **abutment,** the **handle** for lifting "A" **or "B" "stop bolts"** is shifted until the **small pin** coincides with **"B stops in"** on the **index plate;** the **fingers** projecting from the **handle's shank** will then lift the **"A-1 stop bolt"** allowing it to clear the **notch in "A-1 stop bar"** and allow the **"B-1 stop bolt"** to ride on its **"stop bar"** until it reaches the **abutment** as in the case of the **"A-1 stop."**

The **auxiliary stop** is simply a **hardened pin** projecting through the **turret carriage,** and may be used on any **"B" stop bar.** The **"stop bolts,"** however, are always used, except in rare cases where extra stops are required.

Note the oil reservoir which leads to a roller on the under surface of the turret, providing ample and convenient means of lubrication. The "annular gib" is an important factor in keeping the turret perfectly rigid.





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Efficiency and dependability are required of every industry's master workman. Whether he be called Foreman, Master Mechanic, Master Patternmaker, Master Brickmaker, Head Miller or Mine Boss, he must effectively change orders into product.

Efficiency and dependability are built into G-E Motors, which are used to turn the wheels of industry the world over. Wherever used, G-E Motors are effectively changing electrical into mechanical power—truly they are the master workers of every industry.

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For Texas, Oklahoma and Arizona business refer to Southwest General Electric Company (formerly Hobson Electric Co.), Dallas, El Paso, Houston and Oklahoma City. For Canadian business refer to Canadian General Electric Company, Ltd., Toronto, Ont.

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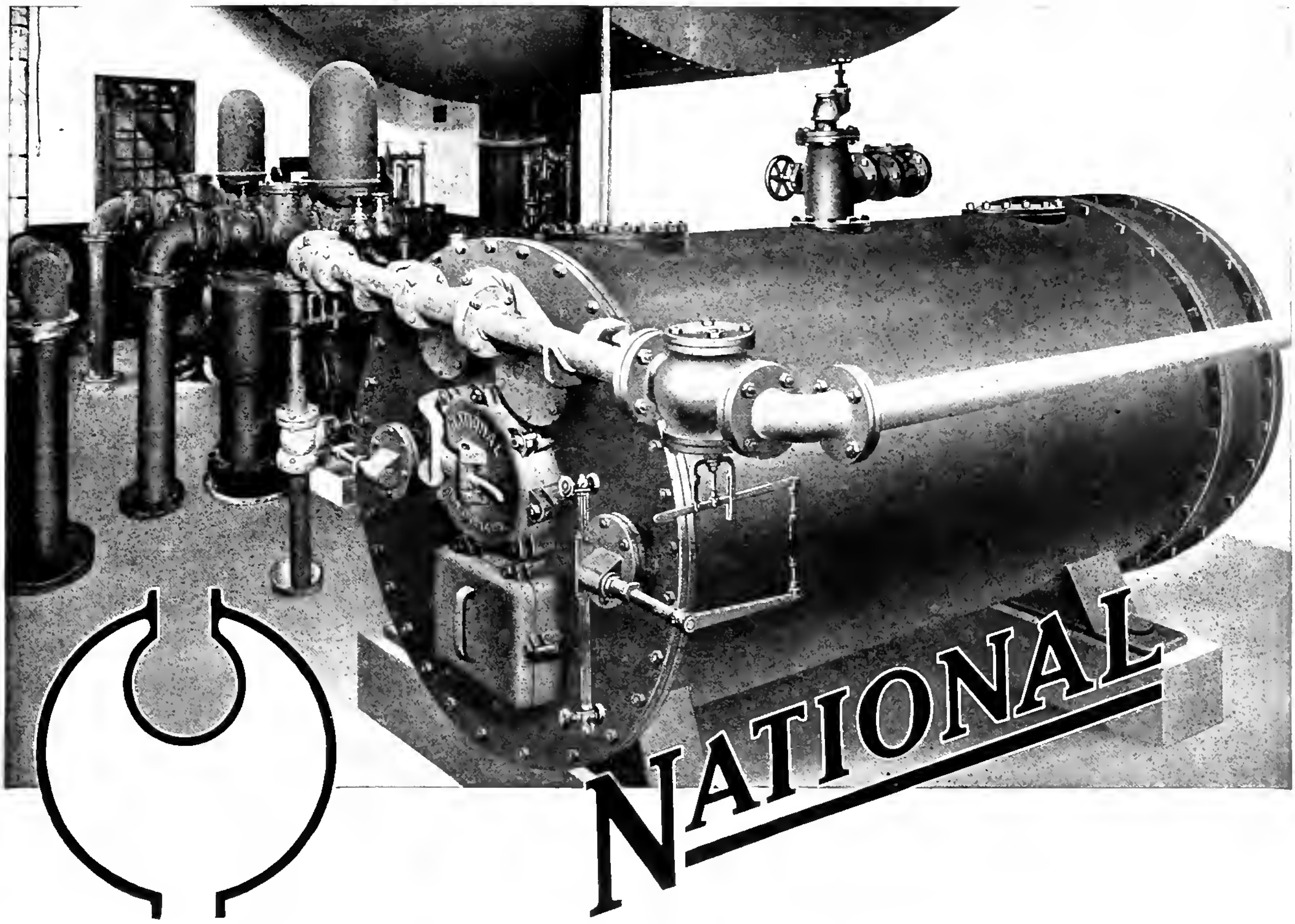

THIS feed water heater, selected for the repair shops of a large railroad, is the product of the company that for more than thirty years has specialized in the manufacture of high-grade heaters.

Beginning with the National closed heater which is so extensively used that more than 3,250,000 horse power have been installed, they added this open heater known as the

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Both surface contact and direct contact are utilized in heating the water to 212°. It is also a purifier with upward filtration, and a storage tank. This type is heating feed water in the following public service corporation plants—in none of which is it of less than 2,000 horse power capacity.

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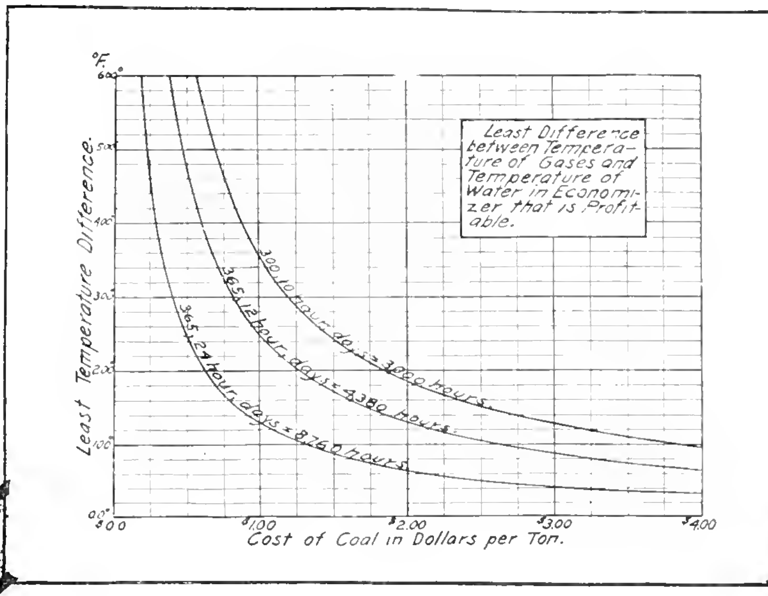
CATALOG NO. 2 DESCRIBES THIS HEATER 40-74

THE NATIONAL PIPE BENDING COMPANY

54 High St., Boston NEW HAVEN, CONN. **149 Broadway, New York**

How Much Economizer Surface Does It Pay To Put In?



ENGINEER Gleichmann, in a report presented at the Munich Convention of the International Association of Steam Boiler Inspecting Societies, says:

> "Assuming a uniform load the most economical plant at low feed water temperatures corresponds to a chimney temperature of 266° to 284°; for average feed water temperature, 338° and for high feed water temperature, 392°."

That is, enough economizer surface should be put in to reduce the gases to this temperature before they pass to the chimney.

The above chart, based upon American costs, shows that Engineer Gleichmann's figures are about right for a plant operating at full load 10 hours per day, 300 days per year, with coal $2.00 per ton. With more expensive coal, it would pay to reduce the gases to a lower temperature, while with a lower load factor, not quite so much surface should be installed.

For a given **efficiency,** the **cost** of steam generating plant can be greatly reduced by installing a Green's Economizer, or for the same **cost,** the **efficiency** can be increased; **in either case the cost of steam delivered to the engine is reduced.** The economy of the economizer is the greater the higher the steam pressure employed, the more expensive the fuel and the greater the charge for real estate and buildings.

Green's Economizer is used in the best modern power plants, such as those of the American Sugar Co., American Ice Co., American Woolen Co., Philadelphia Rapid Transit, Clark Thread Co., Corn Products Co., New York, New Haven & Hartford R. R., Interborough Rapid Transit Co., Ivory Soap plant, American Iron & Steel Mfg. Co., Lackawanna Railroad, Michigan Central R. R., N. Y. Central Railroad, Larkin Co., Pennsylvania R. R., Richardson Paper Co., Solvay Process Co., the Standard Oil Co., U.S. Armory, U.S. Mint, Washington Filtration plant, Board of Education, Philadelphia, etc., etc.

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It treats of the "Ingersoll-Rogler Valve," the latest achievement in air compressor engineering and contains information that will interest every user of compressed air.

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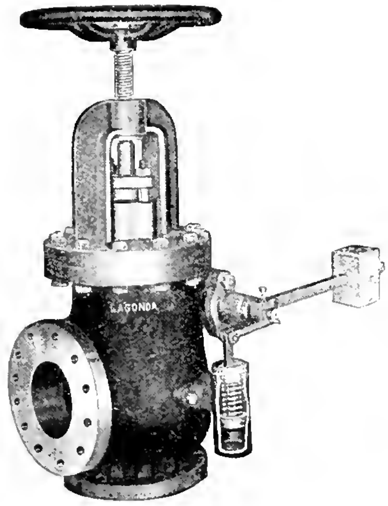

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All of the boilers in the Monumental Brewing Co., of Baltimore, Md., are equipped with Lagonda Automatic Cut-off Valves. On two separate occasions one of their 150-ton refrigerating machines ran away, due to an accident to the governor, and the normal speed of 50 r.p.m. jumped up to 100. At this speed, however, the velocity of the flow of steam through the Lagonda Valve was sufficient to shut it, and the engine was stopped without further damage.

The Lagonda Valve is not an ordinary non-return stop valve. It works both ways.

Write for our Catalog "The Lagonda Automatic Cut-off Valve" and find out why all prominent boiler insurance companies and the U. S. Government recommend the use of these valves.

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There can be no question about the sound business sense of installing "trade-marked goods" of known standing and quality.

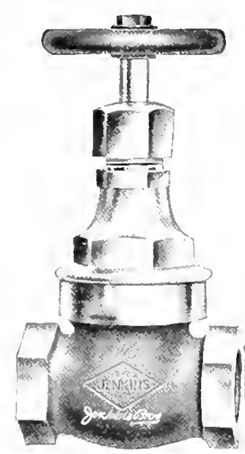
An article which is *not good enough* to be trade-marked, or bear evidence of grade backed by the maker, is not good enough to specify.

Jenkins Bros. Valves are distinguished by their registered trade mark. Specify *Jenkins Bros.* products and you obtain quality and good service.

Jenkins Bros. Gate Valves

Brass Iron Body Cast Steel

The type illustrated this month is the Jenkins Bros. Brass Gate Valve. Particular attention is directed to the *globe shaped body*—a unique and distinctive feature in gate valves, originated by Jenkins Bros. This design secures the greatest possible strength, rigidity, symmetry, and full free opening.



The metal is of the same high grade as used for the Jenkins Bros. Brass Globe and Angle Valves. The valves are all of the solid-wedge, double-face type, therefore simple in construction and free from troubles incident to internal wedging devices.

Made in various styles, stationary spindle, outside screw and yoke, rising spindle, wood wheel, brass wheel, hose end, cap and chain, quick opening; and in Standard, Medium and Extra Heavy Patterns.

Write for catalogue descriptive of the entire line.

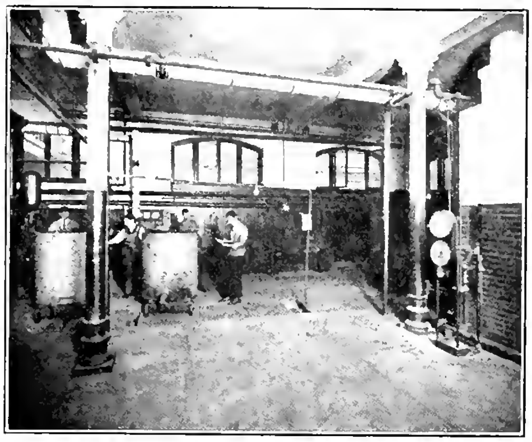
Jenkins Bros.

New York, Boston, Philadelphia, Chicago

Jenkins Bros., Limited, Montreal, P. Q., London, E. C.

Venturi Accuracy is Demonstrated in the Leading Technical Schools

The fact that the leading technical schools and colleges throughout the country have permanent Venturi testing equipment installed illustrates their high opinion of this form of measurement for boiler feed and other service. The illustration shows the students of Drexel Institute at Philadelphia, demonstrating the high accuracy of the Venturi by weighing the feed water on platform scales. A 2" Venturi Meter Tube connected with a Type M Indicator-Recorder performs the dual service of continuously checking the efficiency of the boilers and also providing an instructive exercise in power plant economy. This meter has been installed since 1912 and its two years of service measuring hot water at very high temperatures is proof of Venturi accuracy and durability.



Students Testing Venturi Meter at Drexel Institute, Phila.

Among other well known Venturi-equipped technical schools and colleges are:

Massachusetts Institute of Technology
Worcester Polytechnic Institute
Lehigh Institute
Harvard University
Brown University
Case School of Applied Science
Michigan Agricultural College
University of Texas
University of Illinois
Leland-Stanford University
Johns Hopkins University

Why not avail yourself of the experience of these laboratories? A Venturi meter would improve your boiler plant economy. Write for Bulletin No. 68 M. Yours without obligation.

Builders Iron Foundry, "Builders of the Venturi," **Providence, R. I.**

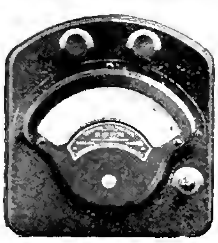
New York Pittsburgh Chicago San Francisco Portland Seattle

WESTON

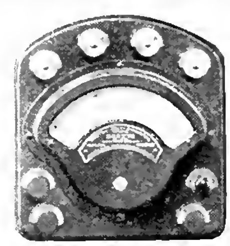
Miniature Precision Instruments for Direct Current

A new group of very small Indicating Instruments

COMPACT — ACCURATE — DURABLE — BEAUTIFUL



MODEL 280, Single Range Portable Voltmeter.
(One-quarter Size.)



MODEL 280, Triple Range Portable Volt-Ammeter.
(One-quarter Size.)

PORTABLE

Voltmeters, Millivoltmeters, Volt-Ammeters, Ammeters, Mil-Ammeters, are supplied in single, double and triple ranges

The triple range volt-ammeter comprising six instruments in one. This group also includes BATTERY TESTERS

SWITCHBOARD

Voltmeters Volt-Ammeters Ammeters Mil-Ammeters

This new line of instruments represents the latest development of the pivoted moving coil, permanent magnet type for low ranges.

The refinement of design and mechanical work in them has been carried to a degree which would appear to be almost impossible of accomplishment, if the results were not evident in the instruments themselves.

They embody characteristics which have made the well known Weston Standards famous throughout the world.

They are accurate, dead beat and extremely sensitive.

They may be left continuously in circuit at full load without injury and are shielded against the external electrical and magnetic influences of other apparatus in their vicinity.

They are substantially constructed and may be safely sent long distances through the mails and will withstand an extraordinary amount of vibration without injury.

MODEL 267, Switchboard Ammeter.
(One-quarter Size)

MODEL 268, Switchboard Volt-Ammeter. Reads Amperes. Press Button for Volts. (One-quarter Size.)

They have the longest scale ever provided in instruments with equal length of pointer.

Each model has been thoroughly tested under the most severe conditions of service and in experiments extending over more than one year.

The portable instruments may be conveniently carried in the coat pocket.

The prices have been established upon so low a scale that any one may possess one or more of these remarkable instruments at moderate cost.

If you cannot obtain the instruments desired from your dealer, write us.

The several models and ranges offer a selection from over 300 different combinations, listed in Bulletin No. 8. Will be mailed upon request.

WESTON ELECTRICAL INSTRUMENT COMPANY, Main Office and Works, NEWARK, N. J.

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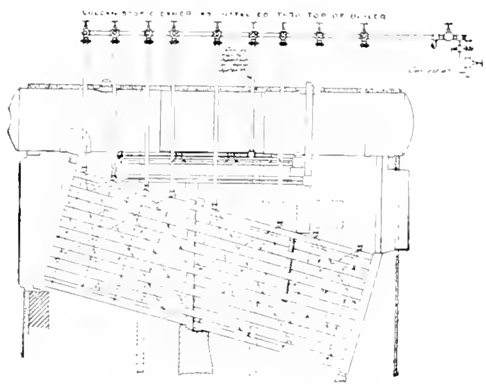
Badt-Westburg Elec. Co., 832 Monadnock block, Chicago, Ill.
F. E. Gilbert, 303-4 Hale Bldg., 1326 Chestnut Street, Philadelphia, Pa.
Geo. H. Moseman, 176 Federal St., Boston, Mass.
Milton Mill, 915 Olive St., St. Louis, Mo.
B. K. Sweeney Electrical Co., 2910 Huron St., Denver, Colo.
Frank E. Smith, 682 Mission St., San Francisco, Cal
S. C. Dinsmore, 1933 Dime Bank Bldg., Detroit, Mich
Walter P. Ambos Co., 1729 East 12th St., Cleveland, Ohio.
A. H. Winter Joyner, Ltd., 76 Bay St., Toronto, Canada.
Weston Instrument Co., Ltd., Geneststrasse 5, Schoneberg, Berlin, Germany.
D. R. Petest, 415 Fourth Nat'l Bank Bldg, Atlanta, Ga.
Edwin Wortham, Suite 28, Allison Building, 8th St., & Main St., Richmond, Va.
Montreal, Winnipeg, Vancouver, Calgary } Northern Electric Company Limited
Weston Electrical Instrument Co., Audrey House, Ely Place, Holborn, London, E. C

THE 201ST STATION

OF THE UNITED ELECTRIC LT. & PWR. CO.
NEW YORK CITY

is equipped with



VULCAN SOOT CLEANER
Top Installation

32 VULCAN SOOT CLEANERS

because the VULCAN SYSTEM proved to be the easiest and quickest way of getting rid of soot. SIDE BLOW DOORS WERE OMITTED to prevent air leakage. The VULCAN, by being installed thru the top of the boiler, permitted the boilers to be set closer together, thereby **saving valuable floor space.**

Send for our book "Economical Steam Production" on the subject of "Soot in Relation to Boiler Efficiency." It is of much interest to Mechanical and operating engineers. A complimentary copy will be mailed promptly upon request.

G. L. SIMONDS & CO. **228 So. La Salle St., Chicago**

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JAR
REG U.S PAT OFF

The Best Steel

obtainable might be made into wire which would be too hard and brittle to make a good wire rope.

Or the wire might be of a quality that would stand all tests and yet make a poor rope, because of lack of care and skill in stranding, or because of an improper design.

The good rope, the kind which wears well and gives satisfactory service, is made from wire of uniform quality, stranded together in a workmanlike manner in accordance with designs, planned in the light of experience in manufacture and close study of the operation of wire rope in use.

The rope that bears the above trade mark is known wherever wire rope is used as one which wears well and gives the best service of which wire rope is capable.

Such a reputation is not an accident but the natural result of a thorough appreciation of what must be done to make a good rope, and the necessary facilities for doing it.

John A. Roebling's Sons Co., Trenton, N. J.

POWER PLANT EQUIPMENT

ALMY WATER TUBE BOILER CO.
PROVIDENCE, R. I.

Manufacturers of Almy Patent Sectional Water Tube Boilers for steamships, river steamers, both propeller and stern wheel, torpedo boats, fire boats, launches. Donkey Boilers for steamships and for all kinds of stationary work.

Water Tube Boilers

AMERICAN STEAM GAUGE AND VALVE MFG. CO.
BOSTON, MASS. ESTABLISHED 1851

Pressure and Recording Gauges, Engine Room Clocks and Counters for all purposes. Iron and Brass Pop Safety and Relief Valves for stationary, marine and locomotive use. The American Thompson Improved Indicator with new improved detent motion. The American Ideal Steam Trap.

See pages 110, 111 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Valves

Gauges

Indicators

W. N. BEST
11 BROADWAY NEW YORK CITY

Apparatus for and technical information relative to all forms of liquid fuel equipment.

Oil and Tar Burners

Furnaces

CHAPMAN VALVE MANUFACTURING CO.
INDIAN ORCHARD, MASS.

BOSTON NEW YORK ST LOUIS PITTSBURGH CHICAGO PHILADELPHIA SAN FRANCISCO

Brass and Iron Valves for steam, water, gas, oil, etc. Sluice Gates. Send for catalogue.

See page 76 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Valves

CRESCENT MANUFACTURING CO.
SCOTTDALE, PA.

Lackawanna Sight Feed Lubricators and Automatic Grease Cups

Lubricators

Grease Cups

EDGE MOOR IRON COMPANY
EDGE MOOR DELAWARE

Builders of the Edge Moor Water Tube Boiler. Especially suitable for large power plants. Steel construction, straight tubes, all hand holes elliptical, unrestricted circulation which permits forcing fires with safety and economy.

See page 23 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Water Tube Boilers

ERIE CITY IRON WORKS
ERIE, PA.

Boilers: water tube, horizontal tubular, return tubular, water bottom portable, open bottom portable, vertical tubular and vertical water tube. Engines: Erie City "Lentz," four valve, enclosed high speed, automatic, center crank, side crank, portable and Feed-Water Heaters from 25 to 600 h.p.

Steam Boilers and Engines

Feed-Water Heaters

HARRISBURG FOUNDRY & MACHINE WORKS
HARRISBURG, PA.

Manufacturers of Fleming-Harrisburg Horizontal Engines, Corliss and Single Valve, Simple, Tandem and Cross Compound.

Steam Engines

HOMESTEAD VALVE MANUFACTURING CO.
WORKS: HOMESTEAD, PA. PITTSBURG, PA.

Manufacturers of "Homestead Valves." Straightway, Three-way and Four-way, for blow-off or for highest pressure and most difficult service for water, air or steam. Valves unlike all others.

See page 82 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume.*

Valves

Valves
Steam Traps
Separators
Regulators

THE HUGHSON STEAM SPECIALTY CO.

CHICAGO, ILL.

Manufacturers of Regulating Valves for all pressures and for steam, air and water. The best and only absolutely noiseless Combination Back Pressure and Relief Valve. Pump Regulators, Separators, Steam Traps, Automatic Stop and Check Valves. Write for complete catalogue.

Magnesia Asbestos and Brine Pipe Coverings

ROBERT A. KEASBEY CO.

100 N. MOORE ST. NEW YORK CITY
Telephone, 6097 Franklin

Heat and Cold Insulating Materials. Headquarters for 85% Magnesia Asbestos and Brine Pipe Coverings, Asbestos Products, etc.

See page 138 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Valves
Blow-off Valves
Fire Hydrants

THE LUDLOW VALVE MFG. CO.

TROY, N. Y.

Manufacturers of genuine Ludlow Gate Valves for all purposes. Special Blow-off Valves. Check Valves. Foot Valves. Sluice Gates. Indicator Posts. Fire Hydrants.

See pages 86, 87 of Condensed Catalogues of Mechanical Equipment, 1913 Volume

Steam Traps

MOREHEAD MANUFACTURING CO.

DETROIT, MICH.

Return, Non-Return, Vacuum and Condenser Steam Traps. The Morehead Tilting Steam Trap is the original design of *tilting* trap, having been on the market for a quarter of a century. For reliable and satisfactory service this type of trap recommends itself. Illustrated descriptive catalog sent on request.

See pages 112, 113 of Condensed Catalogues of Mechanical Equipment, 1913 Volume

Governors

THE PICKERING GOVERNOR CO.

PORTLAND, CONN.

Governors for Steam Engines, Turbines, Gas Engines. Mechanical Control Power Regulation.

See page 131 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Valves
Fire Hydrants

PRATT & CADY COMPANY, Inc.

HARTFORD, CONN.

BRANCHES AT ALBANY, BALTIMORE, BOSTON, CHICAGO, DETROIT, INDIANAPOLIS, NEW ORLEANS, NEW YORK, PHILADELPHIA, PITTSBURG.

Manufacturers of Brass, Iron and Steel Valves, Fire Hydrants, Asbestos Packed Cocks.

See pages 96, 97 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

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Purifying and Filtering Systems

WM. B. SCAIFE & SONS COMPANY

221 FIRST AVE. PITTSBURGH, PA.
26 CORTLANDT ST. NEW YORK

WE-FU-GO and SCAIFE Water Softening, Purifying and Filtering Systems for boiler feed water and all industrial and domestic purposes.

Steam Specialties
Feed Water Heaters
Steam Separators

THE SIMS COMPANY

ERIE, PENNA.

Designers and Manufacturers of Steam Specialties and Power Plant Appliances: Closed Feed Water Heaters, Open Feed Water Heaters, Hot Water Generators-Convertors, Laundry Heaters, Live Steam and Water Mixers, Exhaust Heads, Oil Extractors, Oil Filters, Compound Feeders, Garbage and Refuse Burners, Tanks.

Gas Producers

THE SMITH GAS POWER CO.

LEXINGTON, OHIO

Builders of Smith Automatic Gas Producers, both suction and pressure types. Mechanically Operated Gas Producers in large units for power and heating plants. Tar Extractors and Gas Cleaning Plants.

See page 22 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Engines
Refrigerating Machinery

THE VILTER MFG. CO.

Established 1867 — 1070-1088 CLINTON ST., MILWAUKEE, WIS.

Builders of Corliss Engines, Girder or Heavy Duty Type Bed for Belted or Direct-Connected Service, medium or high speed. Ice and Refrigeration Machines.

WALWORTH MANUFACTURING CO. — BOSTON, MASS.

Manufacturers of high grade Brass, Iron and Steel Valves; Power Plant Piping; Screwed and Flanged Fittings; Pipe Fitter's Tools; Genuine Stillson Wrenches, Parmelee Wrenches, Walco-Hex Wrenches

Valves
Power Plant Piping
Wrenches

POWER TRANSMISSION
HOISTING AND CONVEYING MACHINERY

THE BROWN HOISTING MACHINERY CO. — CLEVELAND O. U. S. A. — NEW YORK, SAN FRANCISCO, PITTSBURGH, CHICAGO

Designers and Manufacturers of all kinds of Hoisting Machinery, including Locomotive Cranes, Electric Travelers, I-beam Trolleys, Crabs, Winches, etc., as well as heavy Hoisting Machinery of all descriptions. Also Fercomclave for reinforced concrete roofing.

See page 201 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Hoisting Machinery

H. W. CALDWELL & SON COMPANY — NEW YORK, CHICAGO

Elevating, Conveying and Power Transmitting Machinery. Helicoid and screw conveyors, machine molded gears, pulleys, fly-wheels, rope sheaves and drives, sprocket wheels and chain, buckets, belting, shafting and bearings.

See page 187 of Condensed Catalogues of Mechanical Equipment, 1913 Volume

Conveyors
Elevators
Power Transmission

DODGE MANUFACTURING COMPANY — MISHAWAKA, IND.

Everything for the Mechanical Transmission of Power, Elevating and Conveying; and Water Softeners. Write for "Power Transmission Engineering," the most complete book of its kind published. It will help you in your specifications.

Transmission Machinery
Water Softeners
Rope Drives
Conveyors

THE EASTERN MACHINERY COMPANY — NEW HAVEN, CONN.

Manufacturers of Electric and Belt Power Passenger and Freight Elevators, Hoisting Machines, Friction Winding Drums, Friction Clutches and Friction Clutch Pulleys.

Elevators
Friction Clutches
Pulleys

THE FAFNIR BEARING COMPANY — NEW BRITAIN, CONN. — Sales Agents: The Rhineland Machine Works Co., 140 W. 42nd St. New York City

High grade Ball Bearings made of the finest materials to the closest standards of accuracy in the world. Fafnir Ball Bearing Hanger Boxes can be used in any standard hanger frame.

Ball Bearings

THE HILL CLUTCH COMPANY — CLEVELAND, OHIO

Manufacturers of a complete line of Power Transmission Machinery for belt, rope or gear driving, including the well known Hill Friction Clutches and Hill Collar Oiling Bearings.

See page 156 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Power Transmission

LIDGERWOOD MFG. CO. — 96 LIBERTY ST. NEW YORK

Hoisting Engines—steam and electric, for every use of the contractor, miner, warehouseman, railroads, shipowners, etc. Derricks, Derrick Irons and Derrick Hoists, Cableways for hoisting and conveying, Marine Transfer for coal and cargo handling.

Hoisting Engines
Cableways
Marine Transfers

LINK=BELT COMPANY — PHILADELPHIA, CHICAGO, INDIANAPOLIS

Elevators and Conveyors for every purpose; all accessories; Power Transmission Machinery. The Link-Belt Silent Chain Drive, Coal Tipples, Coal Washeries, Locomotive Cranes, etc.

See page 192 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Elevators and Conveyors

Cranes

THE MORGAN ENGINEERING CO. ALLIANCE, OHIO

Are the largest builders of Electric Traveling Cranes in the world. We also design and build Steel Plants complete, Hammers, Presses, Shears, Charging Machines and all kinds of Rolling Mill and Special Machinery.

Robins Belt Conveyors

ROBINS CONVEYING BELT COMPANY 13 PARK ROW NEW YORK

The Robins Belt Conveyor was the original and is today the standard of this type of conveying machinery. It is successfully and economically conveying ore, rock, coal and similar materials under the most trying conditions of service. Correspondence invited.

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Pulleys

Paper Friction Transmission

THE ROCKWOOD MANUFACTURING CO. 1923 ENGLISH AVE INDIANAPOLIS IND

Rockwood Paper Frictions have proven their unquestioned superiority. You will find our booklets regarding Transmission of Power by Belts and Friction Transmission desirable additions to your engineering library. Furnished free to members upon application.

Cranes

Mono-Rail Systems

SHAW ELECTRIC CRANE CO. MUSKEGON MICH

Address 119 W. 40th St., New York, (*See Manning, Maxwell & Moore, Inc.*)

Electric traveling Cranes for all purposes. Gantry Cranes. Wharf Cranes and Winches. Mono-Rail Systems.

Cranes

Hoists

THE TOLEDO BRIDGE & CRANE CO. TOLEDO, OHIO

Toledo Cranes and Hoists; Coal and Ore Handling Bridges; Grab Bucket Machinery; Electric and Hand Power Cranes, all types, any capacity; Structural Steel for Factory Buildings.

Elevating

Conveying

Power Transmitting Machinery

THE WEBSTER M'F'G COMPANY (Successors to WEBSTER M'F'G CO.) TIFFIN, OHIO
EASTERN BRANCH, 88-90 READE ST NEW YORK

Manufacturers of Elevating, Conveying and Power Transmitting Machinery for all purposes. Over thirty years' experience in this line and extensive facilities for manufacturing give us large advantages. Belt Conveyors for handling cements, ores, sand, gravel, etc. Coal and Ash Handling Systems for power plants and buildings. Chain belting. Gearing.

Power Transmission

T. B. WOOD'S SONS CO. CHAMBERSBURG, PA.

Modern and Approved Appliances for the transmission of Power. Shafting, Couplings, Collars, Hangers, Pulleys, Belt Tighteners, Friction Clutches, Rope Driving Equipments.

See pages 154, 155 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

STEEL WORKS AND ROLLING MILL EQUIPMENT

Engines

Rolling Mill Machinery

MACKINTOSH, HEMPHILL & CO. PITTSBURGH, PA

Engines, single and compound, Corliss reversing and blowing. Rolling Mill and Hydraulic Machinery of all kinds. Shears, Punches, Saws, Coping Machines.

Blast Furnace Blowing Engines

WEIMER MACHINE WORKS COMPANY LEBANON PA

Builders of Blast Furnace Blowing engines and equipments. Cinder and hot metal cars. Furnace Bells and Hoppers. Rolling Mill castings. Special attention paid to quick repair work and work governed by Engineers' specifications.

PUMPS AND HYDRAULIC TURBINES

ELECTRICAL APPARATUS, ENGINEERING MISCELLANY

CLASSIFIED LIST OF MECHANICAL EQUIPMENT

Manufactured by Firms Represented in the Journal of The American Society of Mechanical Engineers

Accumulators, Hydraulic
Alliance Machine Co.
Mesta Machine Co.
Wood & Co., R. D.

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(See Tramways, Wire Rope)

Air Brakes, Compressors, etc.
(See Brakes, Compressors, etc., Air)

Air-Jet Lifts
Schutte & Koerting Co.

Air Lift Pumping Systems
Ingersoll-Rand Co.

Air Tanks and Cylinders
(See Receivers, Air)

Air Washers
General Condenser Co.

Alternators
(See Generators, Electric)

Ammeters, Voltmeters
(See Electrical Instruments)

Ammonia Condensers, Fittings, etc.
(See Condensers, Fittings, etc., Ammonia)

Anvil Blocks
Hooven, Owens, Rentschler Co.

Arc Lamps
(See Lamps, Arc)

Arches, Ingition (Flat Suspended)
Green Engineering Co.

Ash Handling Systems, Pneumatic
Green Engineering Co.

Augers, Power Coal
Fairmont Mining Machinery Co.

Balanced Main Valves
(See Valves, Balanced Distribution)

Barometers
Tagliabue Mfg. Co., C. J.

Ball Bearings
(See Bearings, Ball)

Balls, Brass and Bronze
Auburn Ball Bearing Co.

Balls, Steel
Auburn Ball Bearing Co.

Barrels, Tumbling
Royersford Foundry & Machine Co.

Bearings, Ball
Auburn Ball Bearing Co.

Bearings, Roller
Royersford Foundry & Machine Co.

Bearings, Self-Oiling
Brown Co., A. & F.
Doehler Die-Casting Co.
Falls Clutch & Machinery Co.
Franklin Manufacturing Co.
Jeffrey Manufacturing Co.

Bearings, Thrust
Auburn Ball Bearing Co.

Belt Dressing
Schieren Co., Chas. A.

Belt Lacing
Schieren Co., Chas. A.
Williams & Sons, I. B.

Belt Lacing, Steel
Bristol Co.

Belt Tighteners
Brown Co., A. & F.

Belting, Chain
(See Chains and Chain Links)

Belting, Conveyor
Goodrich Co., B. F.

Belting, Rubber
Goodrich Co., B. F.

Belting, Leather
Schieren Co., Chas. A.
Williams & Sons, I. B.

Belting, Textile
Goodrich Co., B. F.

Bending Machines, Hydraulic
Wood & Co., R. D.

Blocks, Tackle
Clyde Iron Works
Hunt Co., Inc., C. W.
Roebling's Sons Co., John A.

Blowers, Centrifugal
De Laval Steam Turbine Co.

Blowers, Fan
Green Fuel Economizer Co.

Blowers, Rotary
Schutte & Koerting Co.

Blowers, Soot
Simonds & Co., G. L.

Blowers, Steam
Schutte & Koerting Co.

Boiler Coverings, Furnaces, Tube Cleaners, Tubes, etc.
(See Coverings, Furnaces, Tube Cleaners, Tubes, etc., Boiler)

Boilers, Heating
Smith Co., H. B.

Boilers, Locomotive
Clyde Iron Works

Boilers, Marine
Babcock & Wilcox Co.
Keeler Co., E.

Boilers, Tubular
Clyde Iron Works
Keeler Co., E.

Boilers, Water Tube
Babcock & Wilcox Co.
Heine Safety Boiler Co.
Keeler Co., E.

Boring and Drilling Machines
Manning, Maxwell & Moore Inc.

Brass-Working Machine Tools
(See Tools, Brass-working Machine)

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Jeffrey Manufacturing Co.

Buckets, Grab
Clyde Iron Works.
Hunt Co., Inc., C. W.
Jeffrey Manufacturing Co.
Orton & Steinbrenner Co.

Buckets, Self-Dumping
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Hunt Co., Inc., C. W.
Orton & Steinbrenner Co.

Bulldozers
Wood & Co., R. D.

Burners, Oil
Lunkenheimer Co.
Schutte & Koerting Co.

Cable, Wire
(See Rope, Wire)

Cable Railways
(See Railways, Cable)

Cableways, Wire
(See Tramways, Wire Rope)

Cables, Electrical
(See Wire and Cables, Electrical)

Cam Cutting Machines.
Garvin Machine Co.

Car Hauls, Cable
Fairmont Mining Machinery Co.

Carriers and Elevators, Freight, Continuous
Jeffrey Manufacturing Co.
Mathews Gravity Carrier Co.

Cars, Dump
Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.

Cars, Industrial Railway
Hunt Co., Inc., C. W.

Cars, Motor
Hunt Co., Inc., C. W.

Castings, Die-Molded
Doehler Die-Casting Co.
Franklin Manufacturing Co.
Veeder Mfg. Co.

Castings, Iron
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Builders Iron Foundry.
Falls Clutch & Machinery Co.
Hooven, Owens, Rentschler Co.
Royersford Foundry & Machine Co.
Wheeler Condenser & Engineering Co.
Wood & Co., R. D.

Castings, Semi-Steel
Builders Iron Foundry
Hooven, Owens, Rentschler Co.
Wood & Co., R. D.

Castings, Steel
Mesta Machine Co.

Cement, Belt
Schieren Co., Chas. A.

Centrifugal Apparatus
De Laval Steam Turbine Co.

Centrifugal Pumps
(See Pumps, Centrifugal)

Chain Grate Stokers
(See Stokers, Chain Grate)

Chains and Chain Links
Jeffrey Manufacturing Co.

Channeling Machines, Mine and Quarry
Ingersoll-Rand Co.

Charging Machines, Furnace
Alliance Machine Co.

Chimneys, Steel
(See Stacks, Steel)

Chucking Machines
Garvin Machine Co.
Jones & Lamson Machine Co.

Chutes
Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.

Chutes, Gravity Spiral
Mathews Gravity Carrier Co.

Circulators, Feed Water
Schutte & Koerting Co.

Circulators, Steam Heating
Schutte & Koerting Co.

Clamps, Pipe-Joint
Yarnall-Waring Co.

Clamps, Wire Rope
(See Wire Rope Fastenings)

Clutch Leathers
(See Leathers, Automobile)

Clutches, Friction
Brown Co., A. & F.
Falls Clutch & Machinery Co.
Jeffrey Mfg. Co.
Moore & White Co.

Coal and Ash Handling Machinery
Green Engineering Co.
Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.

Coal Crushers
Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
Orton & Steinbrenner Co.

Coal Mine Equipments and Supplies
Fairmont Mining Machinery Co.
Jeffrey Mfg. Co.

Coal Mining Machinery
Ingersoll-Rand Co.
Jeffrey Mfg. Co.

Coaling Stations, Locomotive
Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.

Cocks, Air and Gage
Ashton Valve Co.
Jenkins Bros.
Lunkenheimer Co.

Cocks, Three-way and Four-way
Lunkenheimer Co.

Coils, Pipe
National Pipe Bending Co.

Coke Oven Machinery
Alliance Machine Co.

Cold Storage Plants
De La Vergne Machine Co.

Combustion Recorders
Simonds & Co., G. L.

Compressors, Air
Devine Co., J. P.
Goulds Manufacturing Co.
Hooven, Owens, Rentschler Co.
Ingersoll-Rand Co.
Mesta Machine Co.
Nordberg Mfg. Co.

Compressors, Air, Centrifugal
De Laval Steam Turbine Co.

Compressors, Compound Air
Ingersoll-Rand Co.
Nordberg Mfg. Co.

Compressors, Gas
Hooven, Owens, Rentschler Co.
Ingersoll-Rand Co.
Mesta Machine Co.
Nordberg Mfg. Co.

Condensation Pumps with Automatic Receivers
(See Pumps, Condensation, with Automatic Receivers)

Condensers
Devine Co., J. P.
Nordberg Mfg. Co.

Condensers, Ammonia
De La Vergne Machine Co.

Condensers, Barometric
Mesta Machine Co.
Wheeler Condenser & Engineering Co.
Wheeler Mfg. Co., C. H.

Condensers, Jet
General Condenser Co.
Schutte & Koerting Co.
Wheeler Condenser & Engineering Co.
Wheeler Mfg. Co., C. H.

Condensers, Surface
General Condenser Co.
Wheeler Condenser & Engineering Co.
Wheeler Mfg. Co., C. H.

Controllers, Automatic, for Temperature or for Pressure
(See Regulators)

Controllers, Electric
General Electric Co.

Converters, Synchronous
General Electric Co.

Conveying Machinery
Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
Mathews Gravity Carrier Co.

Conveyors, Belt
Jeffrey Manufacturing Co.

Conveyors, Bucket, Pan or Apron
Hunt Co., Inc., C. W.
Jeffrey Manufacturing Co.

Conveyors, Gravity
Mathews Gravity Carrier Co.

Conveyors, Gravity Roller
Mathews Gravity Carrier Co.

Conveyors, Screw
Jeffrey Manufacturing Co.

Cooling Ponds, Spray
Schutte & Koerting Co.

Cooling Towers
Wheeler Condenser & Engineering Co.
Wheeler Mfg. Co., C. H.

Copper, Drawn
Roebling's Sons Co., John A.

Copper Wire and Cables
(See Wires and Cables, Electrical)

Copper Converting Machinery
Alliance Machine Co.

Corliss Engines
(See Engines, Corliss)

Counters, Revolution
Ashton Valve Co.
Bristol Co.
Veeder Mfg. Co.

Countershafts and Belt Shifters
Builders Iron Foundry

Counting Machines, Automatic
Veeder Manufacturing Co.

Couplings, Flexible
Falls Clutch & Machinery Co.
Hooven, Owens, Rentschler Co.

Couplings, Pipe
Lunkenheimer Co.

Couplings, Shaft
Brown Co., A. & F.
Cumberland Steel Co.
Falls Clutch & Machinery Co.
Jeffrey Mfg. Co.
Moore & White Co.
Royersford Foundry & Machine Co.

Couplings, Union
(See Unions)

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ALPHABETICAL LIST OF ADVERTISERS

See Pages 41-45 for Classified List of Mechanical Equipment

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

29 West 39th Street, New York

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

INCLUDING THE TRANSACTIONS OF THE SOCIETY

NOVEMBER · 1914

ANNUAL MEETING, NEW YORK CITY, DECEMBER 1-4

A MEMBERSHIP OF SIX THOUSAND

DURING the past month the membership of the Society passed the six thousand mark in its steady, vigorous growth. There has been a gain of over 12% during the past ten months. This is indicative of the increasing strength of the Society and of its present healthy condition. The broad interest which the Society has taken during recent years is making its value felt by the many industries which depend upon the engineer for development.

The membership of the Society at present, however, is small compared with the number of engineers actively engaged in the various industries. Let us consider, for instance, the number of men entering the profession each year.

There are 129 colleges in the United States, giving courses in engineering. From only 32 of these, where Student Sections have been established, 841 students in mechanical engineering alone were graduated last June, all eligible for Junior membership in the Society. In addition to these are the 97 other colleges for which figures have not been compiled. Furthermore there are 52 colleges of Agriculture and Mechanic Arts, with an enrollment of over 8000 students taking four-year courses, and about 20 secondary technical schools graduating annually over 2500 students, most of whom go into industrial activities. In addition, there are the numerous capable engineers who have obtained their training through practical experience, supplemented by private tutoring. A conservative estimate of the total number of competent engineers in the United States alone, not now members in the Society, based on the foregoing facts, would be at the very least 20,000.

The membership invites all well qualified engineers to apply so that the Society may have their coöperation in the work it is doing for the development of the profession.

Total Membership of the Society, October 28, 1914 6004
New Members since January 1, 1914 752

Annual Meeting invitations are now ready for distribution and will be mailed to friends of members upon request.

CHANGE OF ADDRESS

Members who have changed their addresses during the past year and who have not notified the Society are requested to fill out the blank below as indicated and return it to the Society. These corrections are for use in the Year Book for 1915, and should be received by December 15 to insure their appearance.

(Cut off along this line)

The American Society of Mechanical Engineers

29 West 39th Street, New York

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(Fill in every space below. Write distinctly. Typewriting preferred)

Underline the Mail Address

Name...

Title or Position...

Name of Firm...

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A new Year Book is about to go to press. Please return this sheet not later than December 15, 1914

THE JOURNAL OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

Volume 36 NOVEMBER 1914 Number 11

CONTENTS

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COMING MEETINGS OF THE SOCIETY

November 10, *New York City.* Paper: The Development of the By-Product Gas Producer Industry in Europe, by Arthur H. Lymn, London, England, inventor of the Lymn process. Informal dinner, 6.30 p.m.

November 18, *Boston, Mass.* Meeting under the auspices of the Boston Society of Civil Engineers. Address: The Commission-Manager Form of Government and its Relation to the Engineering Profession, by Henry M. Waite, City Manager, Dayton, Ohio.

November 18, *New Haven, Conn.* Fall meeting, Mason Laboratory of Mechanical Engineering, Sheffield Scientific School, Yale University. Subject: The Applications of Electricity in Manufacturing. Afternoon session, 3.00 p.m., papers by Chas. F. Scott and others; evening session, 7.30 p.m., addresses by James Hartness, President, Calvin W. Rice, Secretary, and continuation of afternoon discussion. Dinner, 6.00 p.m., in Yale Dining Club.

November 19, *St. Paul, Minn.* Paper: Coal Testing, by V. H. Roerich.

November 20, *Chicago, Ill.*, La Salle Hotel. Subjects: A New High-Pressure Safety Boiler, W. H. Winslow, president, Winslow Safety High-Pressure Boiler Co.; Boiler Furnace Efficiency, Joseph W. Hays, combustion engineer; Boiler Efficiency Meters and European Boiler Practice, W. A. Blonck, consulting engineer; Mechanical Filters, Walter H. Green, chief engineer, International Filter Co. A dinner will precede the meeting, commencing at 6.30 p.m.

November 21, *Philadelphia, Pa.* Joint meeting with Engineers Club. Paper: Bituminous Coals, Predetermination of their Clinkering Action by Laboratory Tests, by F. C. Hubley, assistant engineer of tests, American Bridge Co.

Annual Meeting, December 1–4, *New York City.* For program see p. III.

December 8, *San Francisco, Cal.* Paper: A Novel Method of Handling Boilers to Prevent Corrosion and Scale, by Allen H. Babcock, Consulting Electrical Engineer, Southern Pacific Company.

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

Volume 36 November 1914 Number 11

THE ANNUAL MEETING

DECEMBER 1-4, 1914

THE feature of the professional sessions will be the all-day session on December 3, on the engineer in public service, which is in line with the wide-spread movement among engineers to devote their special training to public problems. There will also be five sessions on miscellaneous subjects. The exhaustive report of the Committee on Boiler Specifications will probably be ready for discussion at the opening session. On Wednesday evening it is expected that the John Fritz Medal will be awarded to Prof. John E. Sweet, Honorary Member and Past-President, to whom more than to any other living man the formation of the Society is due. Altogether the program is one of the strongest and most interesting in recent years.

TENTATIVE PROGRAM

Tuesday Evening, December 1, 8.30 p.m.

President's Address, by James Hartness

Report of Tellers of election of officers

Introduction of President-elect

Reception by the Society to the President, President-elect, ladies, members and guests in the rooms of the Society. Music and refreshments

Wednesday Morning, December 2, 10.00 a.m.

Business meeting. Reports of the Council and Standing Committees. Reports of Special Committees.

PROFESSIONAL SESSION

FLOOR SURFACES IN FIREPROOF BUILDINGS, Sanford E. Thompson

(CONTRIBUTED BY THE SUB-COMMITTEE ON INDUSTRIAL BUILDING.)

REINFORCED-CONCRETE FACTORY BUILDINGS, F. W. Dean

(CONTRIBUTED BY THE SUB-COMMITTEE ON TEXTILES.)

Wednesday Afternoon, 2.00 p.m.

PROFESSIONAL SESSION

MEASURING EFFICIENCY, H. L. Gantt

STANDARDIZATION IN THE FACTORY, C. B. Auel

(CONTRIBUTED BY THE SUB-COMMITTEE ON MACHINE SHOP PRACTICE.)

OPERATION OF GRINDING WHEELS IN MACHINE GRINDING, Geo. I. Alden

FRICTION LOSSES IN THE UNIVERSAL JOINT, P. F. Walker and W. J. Malcolmson

RAILROAD SESSION (SIMULTANEOUS)

STEAM LOCOMOTIVES OF TODAY: Report of the Sub-Committee on Railroads

Wednesday Evening, 8.30 p.m.

It is expected that the John Fritz Medal will be awarded to Prof. John E. Sweet, Honorary Member and Past-President of the Society.

Following this will be an address of unusual interest, the subject of which cannot as yet be definitely announced.

Thursday, December 3

All-day session, commencing 10.00 a.m., on Engineering in the Administration of a City. Papers contributed by the Committee on Public Relations. The session will be opened by John Purroy Mitchel, Mayor of the City of New York, and contributions have been arranged for upon a wide variety of subjects such as is indicated in the following tentative list: The collection and disposal of refuse from an engineering standpoint and the utilization of municipal wastes; the handling of sewage sludge; the training of municipal employees; the cleaning of public buildings; the future of the police arm presented from the engineering side; the problem of organization as related to the highway department; controlling factors in municipal engineering; cleaning filter sands; the design and operation of a municipal electric light plant; and municipal colleges in Germany.

Thursday Afternoon, 2.00 p.m.

IRON AND STEEL SESSION (SIMULTANEOUS)

FACTORS IN HARDENING TOOL STEEL, John A. Mathews and Howard J. Stagg

(CONTRIBUTED BY THE SUB-COMMITTEE ON IRON AND STEEL.)

STANDARDIZATION OF CHILLED IRON CRANE WHEELS, F. K. Vial

(CONTRIBUTED BY THE SUB-COMMITTEE ON HOISTING AND CONVEYING.)

THE MECHANICAL ELIMINATION OF SEAMS IN STEEL PRODUCTS, NOTABLY STEEL RAILS, R. W. Hunt

TOPICAL DISCUSSION ON ALLOY STEELS

Thursday Evening, 7.00 p.m.

Dinner dance, Hotel Astor

Friday Morning, December 4, 10.00 a.m.

PROFESSIONAL SESSION

A RATE-FLOW METER, H. C. Hayes

A NEW VOLUME REGULATOR FOR AIR COMPRESSORS, Ragnar Wikander

PHYSICAL LAWS OF METHANE GAS, P. F. Walker

LABORATORY FOR TESTING AND INVESTIGATING LIQUID FLOW METERS, W. S. Giele

THE CLINKERING OF COAL, Lionel S. Marks

ANNUAL MEETING PAPERS

On the preceding page is given a tentative program for the Annual Meeting with the papers listed in so far as it is possible to announce them at the date of going to press. Besides the papers listed there will be a series of papers for the all-day session on Thursday upon the general subject of Engineering in the Administration of a City. These latter papers are now in the hands of the Committee on Meetings and full announcement of them will be made as early as possible.

The chief interest of the Annual Meeting will undoubtedly center about this Thursday session. The individual papers are such as will attract attention and a large attendance is expected of engineers from different parts of the country who are interested in this rapidly growing phase of the work of the engineer.

All of the papers for the Annual Meeting will be published in pamphlet form in advance for distribution and copies of any or all of them will be sent to members prior to the meeting upon request. In so far as possible abstracts to be presented are given below and it may be assumed that the list is practically complete as published, with the exception of the papers for the Public Service meeting. The papers are given in the order in which they appear in the program.

FLOOR SURFACES IN FIREPROOF BUILDINGS

By Sanford E. Thompson

No one type of floor surface is adapted to all conditions, and having selected the proper type, the choosing of the materials and the manner of the construction govern to a large extent the durability of the surface.

It is the purpose of the paper to discuss briefly the different kinds of floor surfaces; indicate the types of construction which may be selected under different conditions; give approximate costs of various floor surfaces; describe tests and investigations of granolithic construction made in connection with the new buildings for the Massachusetts Institute of Technology, and present recommendations for granolithic construction.

Summarizing the discussion on the characteristics of floors:

Granolithic. As ordinarily laid in buildings, granolithic or concrete surfaces are subject to dusting and under heavy traffic, such as trucking, are liable to serious wear. On the other hand, experience with first-class construction and tests of actual floors show that it is possible, by proper selection of the aggregates and expert workmanship, to reduce the dusting to an insignificant amount and to produce a surface hard enough to stand even severe wear.

Granolithic with Ground Surface. Experimental surfaces, together with laboratory tests made as a check, show that a pleasing surface, approaching terrazzo in appearance and fully as durable under foot traffic, can be obtained by placing granolithic with scarcely any troweling, and then grinding the surface just enough to expose the grains of sand and stone.

Linoleum. The hardness characteristic of granolithic finish is overcome by covering the surface with battleship linoleum.

Hardwood Floors. Floors of maple, birch, beech, oak or long-leafed Southern pine, are used most largely for offices, class-rooms, or lecture rooms, and in many of the older colleges for laboratories and halls. A wood surface, however, is not usually considered entirely satisfactory either in general appearance or in wearing qualities.

Terrazzo. This is being largely used, especially in the newer office buildings and in institutions, for corridors and halls. It is also a satisfactory material for laboratories.

Marble Mosaic. Mosaic consists of small squares of marble laid on the cement bed, something like terrazzo.

Magnesium Composition. When laid with great care, composition is satisfactory and durable material. Floors six or eight years old have been examined and show satisfactory wear.

Essentials of Granolithic Construction. Aggregates should contain no dust but should consist chiefly of particles ranging from $^1/_{16}$ in. to $^1/_2$ in. in size.

Proportions with first-class materials should be one part cement to two parts aggregate.

This mixture should be of such consistency that it will not flow but will hold its shape in a pile without settling.

A perfect bond must be made with the base concrete either by laying the granolithic before the concrete has set, or else roughening surface and providing a bond of neat cement paste.

Laying must be done at moderate temperatures, avoiding temperatures below 50 deg. fahr.

Troweling should be thorough but no excess water should be brought to the surface. A hard, dense surface rather than a smooth, glossy surface should be the aim.

The surface should be kept wet for at least ten days to two weeks after laying.

REINFORCED-CONCRETE FACTORY BUILDINGS

By F. W. Dean

This paper presents the advantages of the use of reinforced concrete for the use of factory buildings, such as fire-resisting qualities, great window area, and good lighting, and also some of the disadvantages. It also points out that regular mill construction buildings have shown their fire-resisting qualities when properly designed. The best methods of finishing the floors are discussed and also the application of wood as a wearing floor above the concrete. The difficulties of fastening shafting hangers and machinery are brought out and the extra cost of drafting in consequence of this, as well as the great care required in making provision for everything to be installed. The different methods of constructing floors and the different forms of ceilings are taken up and also the relative costs of concrete and regular mill construction buildings.

MEASURING EFFICIENCY

By H. L. Gantt

The author contends that the attempt of the accountant to furnish the financier with easily obtainable measures of efficiency has not only been a failure, but that the attempt to use as measures of efficiency the criteria which he has provided is one of the most serious causes of inefficiency with which the practical manager has to contend.

Fortunately for industry at large, the first fallacy, namely that it is necessary to have low wages in order to get low costs, is rapidly falling into disrepute; but the second, namely, that the ratio of "non productive" to "productive labor" as a measure of efficiency is still strongly and almost universally held by accountants and financiers. This fallacy, on account of its widespread acceptance, is responsible for more inefficiency than almost any other cause.

Inasmuch as the object of increasing the efficiency of an industrial operation is to reduce the cost of that operation, the only real measure of the efficiency with which the operation has been performed is found *in the effect on its cost.*

The only reliable indication, then, of the efficiency of a plant is furnished by the detail shop cost of the operations performed.

Before any great progress in the solution of our industrial problems can be made, the two fallacies above referred to must be abandoned, for they not only directly hamper the operating executive in his efforts to promote efficiency, but impose upon him conditions that make it almost impossible for him to secure the proper coöperation of his employees, and are thus indirectly the cause of much of our industrial unrest.

STANDARDIZATION IN THE FACTORY

By C. B. Auel

A brief outline is given in this paper of the ways and means employed by a large electrical establishment in their work of standardization.

Drawings: It was formerly the custom to make all drawings as complete and self-contained as possible. Opposite each item a note was placed specifying the material required to manufacture it. When drawings for new apparatus were made and any of the old parts could be used, these parts were shown again on the new drawings in complete detail, so that the workmen would not have to refer to any other drawing. This method was found to involve more and more a duplication of drafting and clerical work and the scheme of making elemental drawings with one piece on a drawing was next considered; but, while this insured accuracy in duplication, it had the disadvantage of too many drawings to handle. A compromise arrangement was therefore adopted, consisting of a natural grouping of pieces or parts on a single drawing. Each piece is assigned an item number and a list of the material involved is located conveniently on the drawing arranged numerically according to item numbers.

Manufacturing Information: All apparatus and parts are built to so-called manufacturing information, which consists of a specification setting forth the drawings to be worked to, with a list of the various kinds and amounts of material required. Copies of such portions of these specifications and drawings as pertain are issued to all departments having work to do in connection with an order, and these specifications are closed when the order is completed.

Specifications and Shop Processes: When either the quality or the importance of the items warrant, specifications are carefully prepared for the purchasing and the inspection departments who use them in the purchase and the subsequent inspection of such materials. Another equally important line of work consists in the development of manufacturing processes and formulae which, when standardized, are recorded in permanent form and issued to the various manufacturing departments involved. In this way uniformity in product is assured, there is no needless repetition of lessons or experiences previously learned, and the company is made independent of any individual's knowledge.

Standardization: Owing to the obvious need for having certain standard sizes and kinds of materials, the first steps in standardization naturally fell to the drafting department. Later a standards division of the engineering departments and a Standards Committee were created, whose functions are the standardization of existing materials and parts. The work of the Standards Committee has been varied in the extreme, such matters having been successfully handled as punched circular washers, thumb and wing nuts, oil-hole covers and hinges, furniture, anchor holes in bearings, wood handles, sizes of tap drills, stresses in eye-bolts, thickness of babbitt in bearings, liners, trucks, etc.

Cutting tools have been standardized as well as die and jig parts, die shoes, punches and punch holders, punch and stripper plates, jig boxes and bushings, drill press shanks, etc. Endeavor has been made to place on working drawings the allowable variations from drawing dimensions for standard parts.

Allowances for Expense Materials: The monthly consumption of various expense materials, such as oils, greases, waste, incandescent lamps, janitor's supplies, etc., has been estimated for the individual manufacturing departments, based on normal production. From these investigations, allowances have been set on each item and a department is permitted to draw from the storehouse on requisitions up to its allowance. Anything in excess must first receive the approval of the superintendent of the department.

Handling Materials: Attention has been given to the economical handling of the smaller materials and the paper describes the various devices employed—packing of small pieces in cloth bags, metal tote boxes of special design, etc.; and for transportation, the use of trucks of various types, especially electric storage trucks.

Safety Methods: Well-defined steps have been taken for the systematic introduction of safety methods and devices. A supervisor of safety appliances was appointed and a monthly appropriation issued to cover the cost. No new tools are erected nor old tools replaced without adequate safeguards, by which means dangerous tools or equipment are gradually eliminated. An analysis of the accidents for the past year shows but three-tenths of 1 per cent to have been caused by the absence of safeguards. A campaign of education is conducted to reduce accidents due to carelessness.

Inactive Materials: All stock ledgers are regularly scrutinized by the storekeeping department and slow-moving or inactive items submitted to a materials disposition depart-

ment that investigates not only the cause of the inactivity but at the same time endeavors to dispose of the material to the best advantage.

OPERATION OF GRINDING WHEELS IN MACHINE GRINDING

By Geo. I. Alden, Worcester, Mass.

Long experience in the use of grinding wheels has developed facts in regard to their action which, however, have been stated only as empirical rules. Such rules are easily forgotten or confused by operators because they are not related in any obvious way to any known principles by which results may be predicted. For example, what is the effect upon a wheel of increasing the speed of work, or of increasing the diameter of the work, or of diminishing the diameter of the wheel?

This paper gives an analysis of the action of the wheel when in operation. It shows the distinction between the radial or real depth at which the wheel cuts and the depth which the abrasive grain in the wheel cuts into the material being ground. This latter depth is termed the "grain depth of cut," which is the *controlling factor* in securing the correct working of the wheel.

When a grinding wheel is working properly, the abrasive grain of the wheel may be considered as cutting small chips from the work, and the surface of the work as cutting or wearing away the bond of the wheel. It is quite evident that the greater the grain depth of cut, the more effective will be the action of the work upon the bond of the wheel. So long as the bond is being worn away just as fast as the abrasive grains of the wheel are being worn down, the wheel will continue to work well. If the bond is cut away too rapidly, the wheel will appear too soft, and will wear away too rapidly. If the cutting grains wear down faster than the bond is cut or worn away, the face of the wheel will become glossy, and the wheel will not cut freely. These considerations lead directly to the conclusion that the action of a given wheel on a given kind of work is almost entirely dependent upon the grain depth of cut. If the grain depth is too great, the wheel wears away too rapidly. If the grain depth is too small, the wheel may glaze. It is therefore important to know how the grain depth of cut may be regulated. Further analysis in the paper leads to the following conclusions:

a Other factors remaining constant, increase of work speed increases grain depth of cut, and makes a wheel appear softer

b Similarly, a decrease of wheel speed increases grain depth of cut

c Similarly, diminishing the diameter of the grinding wheel increases grain depth of cut, and increasing the diameter of the wheel decreases grain depth of cut

d Similarly, making the diameter of work smaller increases grain depth of cut. Conversely, making the diameter of work larger makes grain depth of cut smaller

In applying the principle that grain depth of cut is the main factor, the correct relative speeds of work and of wheel must be found by trial for each wheel and each kind of work. When this has been done, the principle of grain depth of cut will enable one to know the direction in which to make the changes of work speed or wheel speed, to adapt the wheel to changes in its own diameter, or to other sizes of the same kind of work.

In the foregoing it is assumed that the object of grinding is to remove stock rapidly. Often, however, the character or finish of a ground surface is of primary importance. From the point of view of grain depth of cut, a smooth surface by grinding would be obtained if the grain depth of cut were very small, and therefore the work speed should be relatively slower for finishing than for roughing. That the bond may be worn away by a very small grain depth of cut, a softer wheel would be used for fine finishing than for roughing. A very hard glazed wheel may sometimes produce a mirror-like surface on the work; the action in this case being a sort of burnishing process.

The paper concludes with the derivation and application of a formula for the grain depth of cut. Several examples are worked out and a table of arcs of contact of wheel and work for a limited range of diameters is given, also a table of values of one of the factors in the formula for grain depth of cut.

FRICTION LOSSES IN THE UNIVERSAL JOINT

By P. F. Walker and W. J. Malcolmson

For three years two standard makes of universal joints of the type employed in automobile transmission mechanism have been under investigation in the laboratory of the Mechanical Engineering Department of the University of Kansas. Each joint has been operated through a wide range of loads and at several speeds common in automobile service. The purpose has been to determine the loss due to friction in the joint under these varying loads and speeds and for all angles of deflection between the shafts up to the maximum for which the joints were designed. In all the tests two joints have been used, connected by a short intermediate shaft, so that power was transmitted from the shaft of one machine to the shaft of the second, which was always held in a line parallel to the first.

Account has been taken of the differences in operating conditions when the forks of the two joints connected to this intermediate shaft were assembled with the axes in the same plane and when assembled with the axes at 90 deg. Reference to the curves showing friction loss and efficiency reveals the fact that the loss with the forks at 90 deg. is practically double that found with the forks in the same plane.

Average results are presented in the form of curves representing actual loss in the joint, and from these corresponding efficiency curves are derived. For speeds from 650 to 100 r.p.m. and for loads above $\frac{1}{4}$ of that for which the joints were designed, the efficiencies are high and practically constant for each angle of deflection. These values for the maximum angles and speeds never falls below 95 per cent. The losses being practically constant when expressed as percentages of load indicates a constant coefficient of friction on the journals of the joint forks, which would be expected under conditions of uniformity in lubrication within the limits of bearing pressure appropriate to the lubricant used

STEAM LOCOMOTIVES OF TODAY

Report of the Sub-Committee on Railroads

The first consistent and systematic plan to secure the utmost power of locomotives within given restrictions of weight

and cross-section clearance was inaugurated 20 years ago. This plan began with an eight-wheel or American type passenger locomotive, built for an eastern railroad in January 1895. This locomotive weighed 116,000 lb., with 74,500 lb. on driving wheels. It provided a tractive effort of 21,290 lb. While this locomotive was not the most powerful in passenger service at that time, it was the first of a chain of passenger locomotives leading in a connected series, by the same builders, up to and including recent designs of the Mountain type, representing the largest passenger type of present practice. This type has four-wheel leading trucks, eight driving wheels and two trailing wheels. The largest of the Mountain type weighs 331,500 lb. with 240,000 lb. on driving wheels and produces a tractive effort of 58,000 lb., or about three times the tractive effort of the first design of the series built during a period of 20 years.

In the year 1898 the engineering and railroad world was interested by the appearance of the largest and most powerful locomotive built up to that time. This was of the Consolidation type with a two-wheel leading truck and eight driving wheels. This locomotive was built in Pittsburgh and for a number of years was the largest and most powerful of its type, and the largest and most powerful locomotive in the world. Its total weight is 330,000 lb., weight on drivers 208,000 lb. and tractive effort 53,300 lb.

Today the most powerful freight locomotive has two leading and two trailing wheels and 24 driving wheels. It gives a tractive effort of 160,000 lb. and weighs 410 tons. This locomotive has hauled a train of 251 freight cars weighing 17,912 tons, exclusive of the locomotive. The total length of the train was 1.6 miles, the maximum speed attained was 14 miles per hour. This required a maximum drawbar pull of 130,000 lb. This locomotive has six cylinders and three groups of driving wheels.

Valuable comparisons in efficiency may be drawn from the best results of ten years ago and of to-day. At the Louisiana Purchase Exposition in 1904 was shown to be possible to obtain equivalent evaporation from and at 212 deg. of 16.4 lb. of water per sq. ft. of heating surface, indicating the power of locomotive boilers when forced. It was shown that when the power was low, the evaporation per pound of coal was between 10 and 12 lb., whereas the evaporation declined to approximately two-thirds of these values when the boiler was forced. These results compared favorably with those obtained in good stationary practice, whereas the rate of evaporation in stationary practice lies usually from 4 to 7 lb. of water per ft. of heating surface per hour. In steam consumption the St. Louis tests showed a minimum of 16.6 lb. of steam per i.h.p. per hr. In coal economy the lowest figure was 2.01 lb. of coal per i.h.p., the minimum figure for coal per dynamometer h.p. was 2.14 lb. These records were made after the superheater had become a factor in locomotive practice and they represent economies attained by aid of the superheater in one of its early applications. This is important in the light of the recent development of the superheater.

Voluminous records of recent investigations of locomotive performance taken from the Pennsylvania Railroad test plant at Altoona show that the best record of dry fuel per i.h.p.-hr. down to the present date is 1.8 lb. with a large number of less than 2 lb., while the best performance in dry steam per i.h.p.-hr. is 14.6 lb. with a large number less than 16 lb. A reduction of 10 per cent in fuel and 12 per cent in water is remarkable as a result of a development of 10 years. This coal performance was recorded by a Class E 6 S Pennsylvania Railroad locomotive while running at 320 r.p.m. and developing 1245.1 i.h.p. The same locomotive gave a fuel rate of 1.9 lb. while running at the same speed and developing 1750.9 i.h.p. The best water rate was given by Class K 2 S A Pennsylvania Railroad locomotive while running at 320 r.p.m. and developing 2033.1 i.h.p. These high powers indicate that the locomotives were not coddled as to output of power in order to show high efficiencies, but that high efficiencies accompany actual conditions of operation in severe service. As to power capacity expressed in terms of evaporation, it is interesting to note that the maximum equivalent evaporation from and at 212 deg. per sq. ft. of heating surface per hour on the Altoona test plant is 23.3 lb.

FACTORS IN HARDENING TOOL STEEL

By John A. Mathews and Howard J. Stagg

The paper is devoted primarily to the practical side of the art of hardening and tempering tool steel, carbon steels being considered in the first place (0.60 to 1.50 per cent carbon).

The authors explain at some length the structural variations of steels as a function of carbon content and temperature, as well as the influence of the critical ranges of temperature on the properties of steel, with particular attention to volume changes (variation of expansion with temperature). In case of overheating, the first cooled portion is hardened first, forming an unyielding shell, and a strain is set up by the slower cooling interior which may lead to cracks and ruptures.

Time of Heating: The time of heating is of extreme importance for the strength of the piece: if the heating is too fast, the temperature through the piece is not uniform, while long heating leads to the formation of abnormal size of grain and weakness of the metal. A very bad practice is quick heating in a furnace which is considerably hotter than the correct hardening temperature.

Speed of Quenching: The metal must be cooled quickly, so as to obtain martensite, which is the correct constituent of hardened steel. The authors illustrate the influence of quenching by two examples which are not however tool steels, and after mentioning, according to Benedicks, the conditions which a liquid must have to exhibit a good quenching power, proceed to report their own tests of various quenching media which included pure water, brine solutions, and various oils. The results obtained are expressed in the form of curves.

Hardness as Affected by Mass: Tests have also been made to determine the relation between hardness after quenching and mass, in the course of which it was found that the smaller the sample, the greater the hardness; and the larger the mass, the smaller the depth of hardness when quenched under similar conditions. In order to produce the same degree of hardness in a small and large section, it is necessary to heat the large section hotter than the small one.

Time and Degree of Drawing Temper: It is preferable in large or intricate pieces to draw the temper immediately after hardening. The decrease of hardness on tempering is theoretically explained and illustrated by data obtained by Professor Heyn, while for the effect of time on drawing the

temper the authors present data of their own tests which show that time at the drawing temperature has a marked effect, the general effect of drawing the temper being the more marked, the greater the initial hardness of the piece. The effect of repeated quenching on the shape of steel was studied by means of several hundred experiments and several thousand measurements (on crucible steel). There are four possible changes in shape (length and diameter) in a cylinder through expansion and contraction and under variable conditions all four were actually produced. Many different results were obtained, as where a steel expanded in length on first hardening, and contracted indefinitely thereafter on repeated hardenings, while another steel expanded in length on two hardenings and contracted on the next two. It was generally found that variable conditions gave variable results, which showed the vital importance of the steel furnished being uniform, chemically and physically. The authors conclude by a brief discussion of the qualifications of furnaces used for heating.

THE STANDARDIZATION OF CHILLED IRON CRANE WHEELS

By F. K. Vial, Chicago, Ill.

In the earlier stages of crane construction, wheels of the general design used in railroad service were adapted to crane service by adding a second flange of about the same section as that of a railroad wheel. This practice worked very well as long as the wheel loads did not exceed those used in railway service. In the heavy types of bridge cranes, however, concentrated wheel loads five times as great as occur in railroad service are required to secure the greatest economy.

The most common troubles with crane wheels are:

a Wheels becoming out of round on account of unequal wear

b Breaking down of metal on account of loads exceeding its bearing power

c Distortion and binding of flanges on account of irregularity in gage of track

d These defects in wheels produce heavy strains throughout the structure, including worn and broken propelling gears

All of these defects are not only annoying, but expensive on account of the interruption of service of important machinery.

The Griffin Wheel Company has undertaken an investigation into these various phases by testing to destruction a large number of full size wheels of various designs in the R. W. Hunt & Company's 300,000-lb. Riehle testing machine. Use was also made of a considerable number of tests made at Purdue University and at the University of Illinois.

Bearing Power of Chilled Iron on Steel Rails. The vertical load to be carried on any wheel is not limited by the capacity of the wheel, but by the carrying capacity of the rail. The bearing power of chilled iron is far in excess of that of a steel rail, and, therefore, may be neglected when considering maximum vertical loads.

The tests show that under like loads, the depression in the rail is inversely as the diameter of the wheel. The larger diameter of wheel makes a larger area of contact, which reduces the pressure per square inch.

Analysis of the Carrying Capacity of Various Rails. Tables are given to show that on a new A. S. C. E. rail the safe maximum limiting load for a 12-in. wheel is 23,000 lb., and for a 33-in. wheel, 38,150 lb. If the top of the rail is flat, 2 in. wide, the limiting load on 12-in. wheels is 78,300 lb. and on 33-in. wheels, 130,000 lb.

Relation of Diameter of Wheel to Traction. The power required for locomotion decreases as the diameter of wheel increases.

A 24-in. wheel requires 25 per cent more power than a 33-in. wheel.

A 16-in. wheel requires 68 per cent more power than a 33-in. wheel.

Relation of Diameter of Wheel to Flange Strength. The strength of flanges increases with the increase in diameter of wheel. With the same dimensions of flange and tread, the flange on a 33-in. wheel is from 26 per cent to 34 per cent stronger than the flange on a 24-in. wheel and from 62 per cent to 92 per cent stronger than the flange on a 16-in. wheel.

Relation of Flange Thickness and Tread Thickness to Flange Strength. The tests show that the relation of flange thickness to tread thickness for crane wheels should be as two is to three. Assuming the strength of a flange $1\frac{1}{4}$ in. thick and tread thickness of $1\frac{7}{8}$ in. as 100, a flange having a thickness of $1\frac{3}{4}$ in. and tread thickness of $2\frac{5}{8}$ in. would be 200. In other words, every $\frac{1}{8}$ in. added to flange thickness with the relative increase in tread thickness increases the flange strength 25 per cent. Chilled iron flanges were tested to above 1,000,000 lb. horizontal pressure without breaking.

Standard Design for Crane Wheels. Various designs of 12 in. to 36 in. double flange wheels were made, giving the maximum safe vertical load and the maximum safe flange pressure for each design. Full details of each wheel are shown in the pamphlet.

THE MECHANICAL ELIMINATION OF SEAMS IN STEEL PRODUCTS, NOTABLY STEEL RAILS

By Robert W. Hunt

Increased weight of rolling stock and speed of traffic have led to increase in size of rail sections, requiring changes in the detail of rail manufacture. Under these conditions it is not surprising that new and unexpected physical weaknesses should develop in the heavier rails. One of the chief troubles has been failures through crescent-shaped pieces breaking out of the rail flanges, followed by at least one, and in many cases several, ruptures across the whole section of the rail. Investigation shows that in practically every instance of such failure there was a more or less pronounced seam running longitudinally in the bottom of the rail near its center. This seam occurs at the top of the curve of the crescent-shaped break and is undoubtedly the point at which the fracture starts.

As a result of an investigation of the subject, T. H. Mathias, assistant general superintendent of the Lackawanna Steel Company, determined that the most certain way of getting rid of seams was to remove that portion of the metal which contained them. He reasoned that the primary causes of seams existed in the ingots and probably were incident to the casting of the ingots. The surfaces of ingots display disk-like apertures, due to entrapped air, which in rolling could easily be elongated into dangerous seams. It was

demonstrated, also, that the surfaces of the ingots are decarburized to the extent of eight to ten points carbon and to a depth of [illegible]/16 in., which must be detrimental to the finished product.

The removal of the surface metal is effected by a hot sawing, or milling operation during the process of rolling. The ingot is first reduced to a point where the product is 75 per cent finished, in the form of a partially shaped bar 60 ft. long, when it is entered between two pinch rolls with the flange side up and forced between two milling saws. A second set of rolls pulls on the bar and aids in holding it in line for the milling operation. The milling saws are 5 ft. in diameter with an 8-in. face and revolve at a peripheral speed of 2500 ft. per min. Metal is removed from the top and bottom of the bar, the main object being to eliminate the seams from the central portion of the bottom of the rail which has been the starting point of the moon-shaped failures, and from the top or bearing surface of the head of the rail.

A RATE-FLOW METER

By H. C. Hayes, Cambridge, Mass.

The meter described is designed to be used for recording a variable flow of water, such as boiler feedwater, where there are sudden fluctuations in velocity head, large changes in temperature, and where low rates of flow have to be recorded. The meter operates through the relation which exists between the velocity of a moving fluid and the change of pressure in a direction perpendicular to the direction of flow.

The author discusses several constructions which might be given to a meter working on this principle. If the conduit is bent in a circular arc, the meter will work well for measuring large values of velocity, but will not be sensitive enough for feedwater purposes. Should the conduit be shaped so that a vortex is formed, a sensitive meter may be constructed so as not to be greatly affected by fluctuations in pressure, for the inertia of the vortical mass will serve to steady the gage readings much as a flywheel does the motion of an engine. The sensitiveness of the meter can be changed by moving the low-pressure vent along a radius of the vortex, and the author shows that the meter can be made to give in this way correct results for any particular temperature, so that the meter would be self-compensating, within certain limits, through causing the low-pressure vent to be moved by an unequal expansion arrangement. The possibility of doing that is proved analytically.

To test the correctness of theory, two models were constructed and tested. The first, constructed for the purpose of determining the variation of pressure along an element of surface of the vortex and along the axis, has shown that the first is practically constant until the outlet of the chamber is nearly reached, and that the second is about constant until the top is closely approached, which indicated that the vents do not need to be placed with great accuracy if they are located in a certain way, and that the meter readings will not be greatly influenced by a slight distortion of the entering stream lines.

The second model was designed to give a linear flow in the outlet, and to allow the low-pressure vent to be moved in a radial direction; there being provided, in addition to the vortex chamber, a second chamber which the water enters from the vortex chamber with a whirling motion, and leaves tangentially. The author made a series of tests with this model, and found, among other things, that the loss of head with the vortex meter in the model is greater than with the venturi meter, but the former is $3^1/_8$ times as sensitive as the latter. By means of a calibration curve he found an equation connecting the meter head with the velocity, the former being proportional to a higher power of the latter than the square, and also found an expression for the ratio of meter head over loss of head through the meter in terms of velocity. Further tests have shown that the error introduced by changing temperature is proportional to the temperature change, and that a slight motion of the thumb-screw, such as can easily be given to it by an unequal expansion arrangement, will suffice to give correct results at all temperatures. He describes such an arrangement of two elements made of invar steel and zinc respectively.

The recording device proposed by the author is described and the mathematical principles underlying its operation presented.

A NEW VOLUME REGULATOR FOR AIR COMPRESSORS

By Ragnar Wikander

After a review of the previously existing types of volume regulators or "unloaders," the author explains the basic principle and method of operation of the new device, which regulates the amount of intake air for air compressors with automatic or poppet type of valves.

In order to decrease the amount of intake air, the suction valves are kept open by force during a part of each discharge period, thereby allowing a part of the air which has been drawn into the cylinder during the suction period to return through the valves, and close as soon as the amount of intake air remaining in the cylinder has decreased so as to correspond to the amount of compressed air required at the time.

The method whereby the closing of the automatic valves at an adjustable point during the return flow of the air or gas is effected, consists simply in a very gradual regulation of the force holding the valves open against the pressure exerted by their springs.

The return flow of the elastic fluid through the valves produces a pressure tending to close them and this pressure constantly increases until the piston has reached the end of its stroke, or very nearly so. The valve will close at the point where this pressure, supported by the pressure of the valve springs, balances and overcomes the force applied for the purpose of regulation.

The application of this regulator to a standard Hall air compressor is illustrated and indicator diagrams show the working of the device. The advantages obtained by application to natural gas compressors are also explained.

THE CLINKERING OF COAL

By Lionel S. Marks

There is a growing feeling that the matter of clinkering ought to be taken care of when making contracts for coal and it is frequently suggested that specifications ought to include the melting temperatures of the ash as indicating the clinkering characteristics of the coal. A number of investigators have been working on this subject and it is in

the hope of bringing out such information as is available that this paper is presented.

The principal difficulty in the determinations of the melting temperature of an ash, is in the definition of melting temperature. An ash is usually composed of a number of constituents of different fusibilities and viscosities. The only method that seems to be available for measuring both melting temperature and viscosity, is the Seger cone method, or some modification of it. It is a rough method of measuring the temperature at which the ash reaches a standard viscosity. The method fails if the most fusible constituents of the ash are very fluid, as a skeleton of the cone may be left standing long after its more fusible constituents are quite fluid. If the cone is placed horizontally projecting over the edge of its support, the indications are more satisfactory, though still far from perfect.

The Seger cone method as carried out in various laboratories, yields results which are extremely variable. A tabulation of such results shows an extreme variation of as much as 700 deg. fahr. between different laboratories. An investigation of the causes of this variation shows that the most important factors are the kind of atmosphere and the rate of heating. If the melting takes place in a reducing atmosphere, the observed temperatures will be from 250 to 450 deg. fahr. higher than in an oxidizing atmosphere. The rate of heating the cone has a marked effect on the apparent fusing temperature, when a thermo-electric pyrometer is used.

Laboratory tests of coal ash by the method finally adopted by the writer when compared with the clinkering results actually observed when burning ten different coals under normal power house conditions, show a general relation between the two, but not definite enough to be reliable.

A further indication obtained from the ash tests seems to be of value when combined with melting temperature observations. This indication is the appearance of the melted cone and the range of temperatures between initial and final bending of the cone. The coals which gave most trouble were also those of which the ash cones showed a very liquid constituent and a small range of temperatures between initial and final bending. For the particular boiler plant investigated, it would seem that an ash with a fusing temperature below 2550 deg. fahr. will probably give trouble if the ash cone shows a fusible constituent; whereas it will not give trouble with a fusing temperature above 2515 deg. fahr. if the ash is viscous.

PHYSICAL LAWS OF METHANE GAS

By P. F. Walker

Methane is the leading element in natural gas from the mid-continental field and its behavior is essentially that of the gas as handled in the pipe lines. The paper starts with data which show values of *PV* as a product, and of specific heat. From these data are derived equations for isothermal, *P*-constant, *V*-constant, and adiabatic curves, all showing consistent variations from the standard equations for perfect gases. It is shown that in certain calculations these variations from the perfect gas laws are sufficient to cause significant errors in computation of equivalent volumes of gas as handled on a commercial scale. It is pointed out that the inadequacy of data of a fundamental sort and conflicting statements of various authorities as to specific heat, make necessary more extensive investigations on the non-perfect gases before the work can be extended to give positive correction factors to use in practice.

LABORATORY FOR INVESTIGATING AND TESTING LIQUID FLOW METERS OF LARGE CAPACITY

By W. S. Giele

The paper develops a general method for testing and calibrating liquid flow meters by means of direct comparison of like quantities as volumes, inches of water head, and rates per unit time, and describes in detail the construction of a laboratory for conducting experiments by this method.

The main portion of the apparatus is contained in a three-story building. Essentially, it consists of a sump tank holding about 1000 cu. ft. of water, from which the water is elevated by means of a turbine-driven centrifugal pump to a constant head tank on the roof of the building. Thence it flows to the standard notch tank which is the standard of measurement for the laboratory. It contains a calibrated V-notch weir and is supplied with a hook gage, water-jacketed to maintain uniform temperature and provided with means for distant magnified observation. This standard notch tank is supported directly from the foundation, independent of other parts of the structure.

From the standard notch the water may be made to pass to either of two volumetric tanks, having a capacity of 525 cu. ft. each, or to a meter under test.

As the capacity of the plant is 110 cu. ft. of water per minute (approximately 412,500 lb. per hour) the large size and range of the various elements necessitated unusual precautions in construction and what is believed to be an original method of centralizing observation and control, minimizing the probabilities of error.

In connection with the detailed description of each element of the plant, original data of calibration and computation of possible error are presented.

The paper concludes with an outline of the method of conducting a typical test and shows a sample log sheet for such a test.

OTHER FEATURES OF THE MEETING

It is expected that on Wednesday evening the John Fritz Medal will be awarded to Prof. John E. Sweet, Honorary Member and Past-President of the Society, to whom more than to any other living man the formation of the Society is due. It was Professor Sweet who, encouraged by Henry R. Worthington and Alex. Holley, visited the principal engineers and worked up the idea which resulted in the first meetings in the offices of the American Machinist and at Stevens Institute of Technology.

It is planned to follow the presentation with an address, but the subject cannot as yet be definitely announced. It is anticipated that it will be one of unusual interest to the engineering profession.

An important phase of the meeting will as usual be the social events and the New York Local Committee will again have charge of these features. The President's Reception will be given on Tuesday evening, December 1, in the rooms of the Society on the eleventh floor of the Engineering Societies Building. The re-

union will this year take the form of a dinner dance and will be held at the Hotel Astor, where the grand ballroom has been engaged for the occasion. Covers will be laid for 350 and there will be dancing between courses. This will constitute the chief social event of the meeting, but there will in addition be several affairs planned by the Ladies Committee.

COUNCIL NOTES

At a meeting of the Council on October 9, 1914, the general subject of the Boiler Code was discussed and Alex. C. Humphreys, E. B. Katte and I. E. Moultrop were appointed a special committee to draft a resolution for consideration of the Council, covering action to be taken on this report. The resolution which was adopted requested the Boiler Code Committee to prepare a reprint of their preliminary report and give all other committees from this and other societies with whom they have conferred full opportunity to concur therewith or submit objections thereto. After this procedure, the committee are requested to report to the Council for its further action.

It was voted that the support of the International Engineering Congress be continued and that every effort be made to make the congress a success.

The action of the Council at its June meeting with regard to discontinuing the publication of Condensed Catalogues was rescinded, and it was voted to continue the volume for the present year. The publication of Transactions for 1914-1915 was also authorized. The Publication Committee was given authority to issue the History of the Society by subscription.

The report of the Committee on the Standardization of Flanges was ordered published in Transactions.

The following appointments were made on sub-committees: Added to the Air Machinery Committee, O. P. Hood, C. C. Thomas, V. C. Bachelder, F. A. Halsey; on the Textiles Committee, Albert C. Duncan and W. E. Hooper, in place of John Eccles, deceased, and H. F. Mansfield, resigned; on the Machine Shop Practice Committee, H. P. Fairfield, H. M. Lucas, R. E. Flanders, in place of those whose terms of office have expired. The formation of a new committee on Protection of Industrial Workers was approved, John H. Barr, chairman; also the appointment of a sub-committee on Fuel Oils of the Research Committee.

The following appointments on local committees were approved: New Haven, H. B. Sargent, chairman, and J. A. Norcross; Buffalo, David Bell, chairman; Los Angeles, W. H. Adams, chairman, F. W. Harris, W. W. Smith, O. J. Root, Paul Weeks.

The establishment of a student branch at the Colorado State Agricultural College, Fort Collins, Colo., was approved, as well as the appointment of Wm. H. Kavanaugh as Honorary Chairman of the Student Branch of the University of Minnesota.

CALVIN W. RICE, *Secretary.*

REPORT OF SPECIAL NOMINATING COMMITTEE

In accordance with the provisions contained in C48 and B28 of the Constitution and By-Laws of the Society, George J. Foran, of New York, has been nominated as Manager, to fill the unexpired term of the late Alfred Noble, by a Special Nominating Committee composed of the following members:

W. H. Norris, F. F. Sanborn, M. S. Hopkins, S. G. McMeen, E. A. Hitchcock, E. B. Katte, W. G. Carlton, R. B. Kendig, C. Schwartz, A. C. Humphreys, A. S. Miller, W. H. Wiley, H. G. Stott, F. G. Marble, R. J. S. Pigott, C. F. Dixon, A. B. Bayles, L. S. Cooley, D. S. Jacobus, R. M. Dixon, C. W. E. Clarke, N. Cheney, W. N. Cargill, W. Goodenough, F. B. Powell, G. L. Knight, C. J. Bancroft, E. Smith, J. H. Libbey, B. R. T. Collins, R. Hutchison, A. C. Ashton, C. W. Hunter, L. A. Mozzini, C. H. Bartlett, F. S. Clark, F. N. Bushnell, A. C. Eckert, C. H. Peterson, J. Lanchinger, J. F. G. Miller, E. Flad, C. T. Westlake, J. Hunter, G. C. Anthony, F. H. Tenney, W. H. Reeves, R. Skinner, G. E. Ferris, L. A. Day, G. M. Peek, W. M. Duncan, W. S. Ashton, J. F. O'Neil, H. R. Setz, A. F. Nagel, M. Rotter, R. Schlatter, J. A. Whitley, H. L. Low, J. H. Boughton, W. C. Morehead, C. H. Fish, W. G. Snow, C. A. Read, F. H. Hayes, D. K. Bertram, J. N. Connet, A. F. Clarke, R. E. Hall, S. B. Paine, A. W. Parker, C. J. Pearson, G. P. Alcott, J. C. Long, W. E. Choate, W. W. Blakeman, L. S. Marks, G. C. Anthony, C. H. Chase, H. B. Gale, W. D. Ford, E. R. Brosius, P. P. Bird, H. E. Troutman, R. A. Widdicombe, W. O. Moody, I. P. Streeter, M. T. Kinnman, O. G. Kelly, F. A. Lindberg, C. C. Douglas, J. E. Lord, P. A. Poppenhusen, A. G. Burke, Jr., R. W. Allerton, E. B. Ellicott, C. J. Bacon, C. W. Naylor, D. H. Maury, C. H. Wheeler, Jr., C. F. Drake, C. R. Bridsey, I. W. Lindquist, A. L. Fitch, W. L. Abbott, I. Junkersfeld, J. W. Barker, D. A. Wallace, W. F. Hendry, F. L. Gilman, H. F. Albright, F. H. Dorner, J. Todd, J. C. W. Greth, J. N. Chester, F. W. Casler, J. F. Diepenbrock, J. M. Graves, R. W. Burtsell, M. W. Taber, W. S. Russell, D. T. Randall, J. A. Vail, J. W. Brown, J. G. Vincent, J. Kuhn, H. D. Church, C. H. Taylor, F. J. Stoddard, A. Dow, H. H. Esselstyn, C. M. Barber, J. B. Mansfield, W. S. Conant, F. C. Osborn, R. T. Wingo, C. E. Sweet, H. S. Hodge, I. C. Tenney, H. A. Conrad, T. E. Coon, H. M. Leland, E. E. Sweet, C. M. Carson, W. C. Leland, L. K. Snell, G. H. Layng, F. Johnson, T. H. Kane, G. A. Orrok, C. B. Grady, C. C. Worth, W. J. Best, F. D. Herbert, W. F. Monaghan, F. E. Idell, R. P. Bolton, W. H. Bradley, H. S. Isham, O. H. Fogg, M. W. Kellogg, G. W. Martin, S. D. Sprong, C. K. Nichols, A. W. H. Griepe, F. T. H. Bacon, E. G. Morrison, H. L. Kellerman, F. W. Heisler, T. E. Murray, L. P. Breckenridge, J. P. Sparrow, W. T. Donnelly, H. L. Aldrich, D. Farrand, N. A. Carle, E. B. Meyer, H. S. Vassar, V. M. Frost, H. Webster, N. S. Slee, P. C. Idell, F. A. Scheffler, E. H. Peabody, E. Mills, H. C. Inslee, W. A. Jones, G. A. Gulowsen, A. P. McClintock, A. W. Smith, W. L. R. Emmet, A. A. Adler, C. F. Schreiber, W. J. Keep, A. C. Wood, T. C. McBride, H. E. Ehlers, J. E. Gibson, H. Hess, W. R. Jones, R. B. Yarnall, A. C. Jackson, T. H. Hinchman, R. Collamore, C. R. Richards, R. S. Allyn, E. C. Lufkin, C. R. Place, J. W. Smith, E. H. Dewson, H. P. Barr, L. H. Mumford, R. H. Kirk, T. Stebbins, W. W. Erwin, H. E. Coffin, L. C. Rogers, S. G. Barnes, E. H. Bingham, W. E. Snyder, A. F. Bucklin, I. T. Peterson, J. A. Hunter, E. K. Hiles, C. J. Angstrom, W. P. Hayes, J. R. Fortune, F. B. Bigelow, F. W. Kelley, W. J. Fullerton, J. F. McElroy, L. L. Brinsmade, F. C. Armstead, H. M. Lane, A. L. Jenkins, J. D. Lyon, S. G. Pollard, C. H. Anderson, B. L. Baldwin, G. W. Simpkinson, W. H. Blauvelt, F. B. Klock, J. M. Flannery, C. K. Mallory, H. F. Dunkle, E. N. Trump, E. A. Barnes, C. L. Griffin, B. N. Bump, W. E. Hopton, F. Pillmore, T. H. Miller, L. A. Zoeller, E. W. King, R. M. Gordon, A. G. Mattsson, G. B. Turnbull, I. E. Moultrop, S. Hosmer, A. B. Chamberlain, J. D. Andrew, R. E. Curtis, C. H. Parker, C. L. Edgar, H. N. Dawes, W. B. Snow, E. J. Clark, C. A. G. Winther, H. M. Latham, E. G. Bailey, F. W. Dean, F. B. Perry, W. A. Johnston, G. B. Haven, E. F. Miller, F. E. Shedd, H. A. Coes, F. W. Reynolds, C. T. Mosman, F. B. Cole, W. F. Uhl, C. E. Burleigh, F. Sargent, W. G. Ely, E. E. Gilbert, F. C. Pratt, O. Junggren, E. D. Dickinson, J. A. Capp, J. Riddell, A. L. Rohrer, R. H. Rice, S. A. Moss, G. M. Campbell, W. Johnson, H. S. Baldwin, A. D. Pentz, W. A. Hall, J. C. Parker, R. D. DeWolf, H. Harding, G. N. Saegmuller, C. L. Bausch, W. D. Wisbart, W. S. Austin, F. W. Lovejoy, W. H. Honiss, R. S. Riley, W. W. Bird, H. P. Fairfield, C. H. Manning, G. I. Rockwood, C. R. Seed, G. I. Alden, J. W. Higgins, W. D. Ennis, S. E. Weir, F. R. Still, S. N. Castle, F. F. Nickel, W. Schwanhausser, E. W. Greene, W. G. Hudson, W. Pressinger, W. M. Fleming, H. M. Chase, H. W. Morrill, C. L. Newcomb, C. G. de Laval, C. H. Jenness, S. M. Green, L. W. Graves, W. H. Damon, C. E. Bliss, B. A. Franklin, E. H. McClintock, R. Shirley, S. Stevens, G. W. Galbraith, L. G. Robinson, B. S. Hughes, W. G. Franz, C. H. Fox, J. T. Fang, W. Tallmadge, M. Coster, W. E. Moore, J. Kennedy, G. Mesta, F. L. Bigelow, A. Kingsbury, R. N. Ehrhart, H. T. Herr, C. B. Auel, F. S. Martin, W. P. Flint, F. B. Corey, E. W. McCallister, F. Hodgkinson, E. M. Herr, O. H. Bathgate, F. F. Harrold, E. R. Norris, C. W. Johnson, W. A. Bole, A. McIver, C. F. Uebelacker, G. W. Bacon, F. Blossom, H. H. Porter, A. B. Jennings, J. D. Bird, W. W. Ricker, A. P. Brockelbank, C. L. Cole, G. P. Symonds, H. H. Barnes, Jr., J. S. Smith, W. H. Boehm, S. G. Neiler, C. E. Wilson, E. P. Rich, H. B. Bryden, C. J. Davidson, D. Lofts, H. C. Gardner, W. S. Monroe, W. H. Traver, J. G. O'Neil, J. Lyman, J. I. Hecht, J. F. O. Stratton, H. M. Montgomery, F. Woodmansee, C. M. Garland, C. G. Y. King, C. M. Allen, J. J. Brown.

An account of Mr. Foran's career is appended herewith:

GEORGE J. FORAN

George J. Foran was born in Boston, Mass., January 22, 1862, and was graduated from the Massachusetts Institute of Technology in 1883. His thesis was a history of the art and design of pumping machinery. Upon graduation, he entered the employment of The Deane Steam Pump Company, leaving them at the end of three years to go with the George F. Blake Manufacturing Company, with which company he was associated at the time of its amalgamation with the International Steam Pump Company. After a brief experience in the shop, he served as salesman in the engineering field for some years, later acting as consulting engineer to the president and treasurer of the Blake Company, with special reference to engineering design and constructing water works, condensing and air compressor installations, tests and investigations in New England. Upon the completion of the new Blake Works at Cambridge, he became its office manager and head of the estimating and cost department, originating the cost system then installed. Later he returned to the engineering sales department, and in 1900 went to New York and has since been manager and chief engineer in responsible engineering charge of the condensor department of the International Steam Pump Company, also serving as consulting engineer in the products of its various allied companies. He was active in originating and designing high vacuum apparatus in its development stage, and was responsible for the design of many installations, including a large number of the important installations of this type in the United States.

Mr. Foran joined the Society in 1887 as a junior, and was promoted to member 1893. He was a member of the Membership Committee of the Society for six years, and of the House Committee for three years.

He is also a member of the Verein deutscher Ingenieure and the American Association for the Advancement of Science and an associate member of the American Society of Naval Engineers. He has done a large amount of original investigation and study in the several fields of mechanical engineering and has occasionally contributed to the various publications and society transactions.

RESOLUTIONS OF THE COUNCIL ON THE DEATH OF ALFRED NOBLE

In the death of Mr. Alfred Noble, the engineering profession has lost one of its greatest members, one of its wisest associates, and one of its most modest scientists.

Mr. Noble was a man of generous impulses, always interested in the success of younger engineers, always ready to help them with advice, and to put before them an opportunity for their success. He was without the slightest professional jealousy, and so in love with his chosen calling that he always hailed the achievements of others with delight because engineering had by them been advanced and the world benefitted. His personality was most charming and The American Society of Mechanical Engineers will long miss his delightful talks and wise advice at its Council meetings, where he was a most welcome member. He may be aptly described as a lovely man, full of gentleness and dignity, and yet possessing a forceful character which fitted him so well as a cherished adviser.

It may not be generally known that Mr. Noble had an influence in the decision of Congress to abandon the sea level plan and adopt the lock system for the Panama Canal. The subsequent events have shown the wisdom of Mr. Noble's advice. A member of Congress and a personal friend of Mr. Noble asked him to state his reasons for advising the lock system in the form of a letter. This was done in a most concise form and was read in the House of Representatives, and thus became incorporated in the Congressional Record, with the result that it convinced the members, and by a large majority they adopted the lock system. Copies of the Record marked at Mr. Noble's letter were given to each Senator, and the argument was equally convincing, so that the Senate confirmed the House action by a large majority.

A glance at Mr. Noble's history will be most edifying to a young engineer as it will be gratifying to his hosts of friends. He was born August 7, 1844, at Livonia, Wayne County, Michigan, where his parents, Charles and Livonia (Douw) Noble, resided on a farm. His grandfather served in the War of 1812, and his ancestors were in the Revolutionary War. His early education was received in the District School of his native place, and during his spare time he worked on his father's farm.

In 1862, when only 18 years of age, he enlisted in the Civil War in the 26th Michigan Volunteer Infantry. From that time until 1865 he served in the Army of the Potomac, taking part in all of the hard and desperately fought battles which that army engaged in against Lee and Stonewall Jackson. At Gettysburg his regiment lost a very large percentage of its numbers. At Chancellorsville, it was by the merest accident that his brigade was not captured by Stonewall Jackson men, but he was lucky in serving through the war without being wounded, and was mustered out of the service in June 1865, with the rank of Sergeant. He then prepared to enter the University of Michigan, and in 1867 became a sophomore, graduating in 1870 with the degree of C. E. He received the degree of LL.D. from his Alma Mater in 1895, also from the University of Wisconsin in 1904.

From 1868 to 1870 he was assistant engineer on river and harbor work on the Great Lakes. From 1870 to 1872 he was in charge of improvements on St. Mary's Falls Canal and St. Mary's River. During this time the first great masonry lock at the Soult, then by far the largest canal lock in the world, was built.

On completion of this work he became resident engineer on the construction of an important bridge at Shreveport, La., over the Red River.

From 1883 to 1886 he was general assistant engineer of the Northern Pacific Railroad.

From 1886 to 1887 he was resident engineer on the construction of the Washington Bridge over the Harlem River, New York City, at that time the largest arch bridge in existence.

From 1887 to 1894 he was resident engineer on the construction of several very large and important bridges over the Mississippi at Memphis and Alton, over the Missouri at Bellefontaine and Leavenworth, and over the Ohio at Cairo.

He was appointed a member of the Nicaragua Canal Board by President Cleveland in 1895. This Board visited Central America and examined the route of the Nicaragua Canal and also the Panama Canal and then returned to the United States, completing its work November 1, 1895.

In June 1899, he was appointed by President McKinley a member of the Isthmian Canal Commission, which was charged with the selection of the best canal route across the American Isthmus, and it has been substantially on the route selected by this Commission that the Panama Canal has been constructed. While on this Commission, Mr. Noble with his colleagues visited Europe to examine the existing canals there and to investigate the data which the French Canal Company had in Paris, and also made several trips to Central America to look more fully into the various canal routes.

In 1905 he was appointed by President Roosevelt a member of the International Board of Engineers to recommend whether the Panama Canal should be constructed as a sea level or a lock canal. This Board consisted of thirteen members, of whom five were nominated by foreign governors. Mr. Noble was one of the minority of five Americans who recommended the adoption of the lock plan. Their views were adopted by the Government, and the Canal has been built in accordance with their recommendations.

In March 1907, he was one of the three appointed by President Roosevelt to visit the Panama Canal to investigate the conditions regarding the foundations of some of the principal structures. This duty was completed in a few weeks. He was obliged to decline a similar appointment two years later.

From the very inception of the plan by this country to build an isthmian canal, and from the commencement of the preliminary investigations and surveys, to the adoption of the final plan, and the commencing of the actual construction of the Panama Canal, Mr. Noble was continuously identified with the project and deserved as much credit for the solution of the engineering problems as any other one who has been connected with this great work.

In July 1897, he was appointed by President McKinley a member of the U. S. Board of Engineers on Deep Water Ways which made surveys and estimates of cost for a ship canal from the Great Lakes to deep water in the Hudson River.

In November 1901, the city authorities of Galveston, Texas, appointed Alfred Noble, along with Henry C. Ripley and General Robert, as a Board of Engineers to devise a plan for protecting the city and suburbs from future inundation. They recommended the building of a solid concrete wall over three miles long and seventeen feet in height above mean low water, the raising of the city grade, and the making of an embankment adjacent to the wall; the whole to cost about three and a half million dollars, which plan has since been carried into effect.

From 1902 to 1909 Mr. Noble was chief engineer of the East River Division of the New York extension of the Pennsylvania Railroad, and was in entire charge of this most difficult piece of work, involving, as it did, a very accurate survey across Manhattan, and the construction of the foundations of the Pennsylvania Station, of the land tunnels and of the East River tunnels, which were very troublesome.

Since 1909 he engaged in general practice as a consulting engineer, the firm name being Noble and Woodard. Probably the most important work dealt with was in relation to the dry docks built for the United States Government near Honolulu. He was also, for a time, Consulting Engineer to the Quebec Bridge Board, also Consulting Engineer for the Board of Water Supply, New York City, and for the Public Service Commission of the First District of the State of New York.

He has been Past President of the Western Society of Engineers, American Society of Civil Engineers, and American Institute of Consulting Engineers.

In 1910 he was awarded the John Fritz Medal for "notable achievements as a Civil Engineer."

In 1910 he was elected an Honorary Member of the Institution of Civil Engineers of Great Britain, a distinction which no other American has ever received.

In 1912 he received the Elliot-Cresson Medal of the Franklin Institute "in recognition of his distinguished achievements in the field of Civil Engineering."

He was married May 31, 1871, to Miss Georgia Speechley, of Ann Arbor, Michigan. They had one son, Frederic Charles, a graduate in Engineering of University of Michigan, 1894, now following his profession in New York City.

There is little to add to this epitome, but it shows the forceful character of Mr. Noble throughout. He won the various honored and honorable positions he so ably filled by merit and perseverance, and his career, cut short in this untimely manner, is an encouragement to every young engineer and a stimulus to the exercise and cultivation of those manly and fearless qualities in the possession of which Mr. Noble so excelled and which have so firmly established him in the affections and admiration of all engineers.

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i.e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by advising the Secretary promptly of anyone whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before December 10, 1914.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE MEMBER

Anderson, Thos. D., Lecturer in Mech. Engrg., Sch. of Mines, Bendigo, Victoria, Australia.

Chapman, Wm. B., Pres., Chapman Engrg. Co., 11 Broadway, New York

Elberson, Leander P., Ch. Engr., La. Irrigation & Mill Co., Crowley, La.

Fichter, Clarence, Maintenance Engr., The Rike-Kumler Co., Dayton, Ohio

Fischer, Fred J., Ch. Mech. Engr., Los Angeles Dept. of Public Service, Los Angeles, Cal.

Friedlander, Max, 243 East 48th St., New York.

Grieve, Albert, Prof., Mch. Design, Lima Sch. of Mining Engrs., Lima, Peru, S. A.

Haigh, Gilbert R., Production Engr., Wm. Tod Co., Youngstown, Ohio.

Hermanson, Theo. H., Supt., Epping-Carpenter Pump Co., Pittsburgh, Pa.

Hessenbruch, George S., Asst. to Ch. Engr. of Pwr. Plants, Union Elec. Lt. & Pwr. Co., St. Louis, Mo.

Hopkins, Walter E., Ch. Engr., Coe Brass Branch, American Brass Co., Torrington, Conn.

Jana, Ashutosh, Cons. & Architectural Engr., Birulia, Haria P. O., Midnapur, Bengal, India

Kerr, Robert L., Engr. in Charge, Testing & Development, Alberger Pump & Condenser Co., Newburgh, N. Y.

McKnight, Wm. V., 310 Washington Ave., Oil City, Pa.

Nuttle, Charles L., Treas., Old Colony Foundry Co., East Bridgewater, Mass.

Ogden, Wm. H., 78 State St., Binghamton, N. Y.

Percy, John C., Mech. Supt., Julius Kayser & Co., Brooklyn, N. Y.

Robinson, Wm., M. M., Eberhard Faber Pencil Co., Brooklyn, N. Y.

Rouband, Arthur, Genl. Foreman, Sao Paul Shops, Central Railroad of Brazil, Rio de Janeiro, Brazil

Sage, Darrow, Supt. of Pwr., Hudson & Manhattan R.R. Co., New York.

Schwarz, Michael, Supt., Schoenthaler Mfg. Co., St. Louis, Mo.

Smerling, Carl, 111 Hart St., Brooklyn, N. Y.

Spear, Lawrence Y., Vice-Pres., Electric Boat Co., Groton, Conn.

Tansley, John A., Plant Engr., with Wm. A. Rogers, Ltd., Niagara Falls, N. Y.

Wintler, James M., Steam Boiler Inspector, Hartford Steam Boiler Insp. & Ins. Co., Hartford, Conn.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Eshlerick, George, Jr., Test Engr., American Engrg. Co., Philadelphia, Pa.

Fast, Gustave, Efficiency Engr., Crown Cork & Seal Co., Baltimore, Md.

Grady, W. H., Asst. Genl. Supt., American Creosoting Co., Louisville, Ky.

Hechler, Fred G., Instr. in Mech. Engrg., Rensselaer Poly. Inst., Troy, N. Y.

Kann, Gustav G., Designing Engr., with Arthur Pentecost, New York.

Lucey, Wm. S., Mech. Engr., Eastman Kodak Co., Rochester, N. Y.

McCollum, J. Grant, Supt. of Constr., New Essex Pwr. Sta., Public Service Elec. Co., Newark, N. J.

Miller, John H., Mech. Engr. with R. S. Kent, Designing Engr., Brooklyn, N. Y.

Root, Virgil A., Charge of Factory Ventilation, Natl. Lamp Wks., General Elec. Co., Cleveland, Ohio

Saurwein, George K., Designing Engr., Constr. Engrg. Dept., Edison Illuminating Co., Detroit, Mich.

Wright, Paul, Cons. Engr., 1104 Brown-Marx Bldg., Birmingham, Ala.

FOR CONSIDERATION AS JUNIOR

Benson, Harvey S., with H. C. Raynes, Inc., Cons. Engrs., Boston, Mass.

Camp, Wm. E., Task-setter & Investigator, Yost Typewriter Wks., Remington Typewriter Co., Bridgeport, Conn.

Crane, Eugene C., Supt. of Constr., Minnesota State Farm, St. Paul, Minn.

Ehrlich, Morris W., Pwr. & Designing Engr., Ives & Davidson, Cons. Engrs., New York.

Fairchild, Fred P., Draftsman, Equipment Dept., Stone & Webster Engrg. Corp., Cambridge, Mass.

Freeman, Clarke F., Industrial Engr., Remington Typewriter Wks., Ilion, N. Y.

Harris, Thos. W., Asst. to Wks. Steam Engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

Nadler, Harry A., Asst. Ch. Engr., Guanica Centrale Sugar Co., Ensenada, P. R.

Nissley, Warren W., Local Mgr., The Concord Gas Co., Concord, N. C.

Rosenfield, Harold, Draftsman, Edison Illuminating Co., Detroit, Mich.

Sengstaken, J. H., 497 Decatur St., Brooklyn, N. Y.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE

Bruyere, Paul T., Cons. Engr., 50 Church St., New York

PROMOTION FROM ASSOCIATE-MEMBER

Cocks, Frank L., Special Designer of Automatic Mchy., Arbuckle Bros., Brooklyn, N. Y.

PROMOTION FROM JUNIOR

Beecher, Henry W., Mgr., Seattle Office, Chas. C. Moore & Co., and Babcock & Wilcox Co., Seattle, Wash.

Bourquin, James F., Genl. Mgr., Paige-Detroit Motor Car Co., Detroit, Mich.

Goetz, Victor J., Refrigerating Engrg., 345 N. 12th St., Philadelphia, Pa.

Katzenstein, Martin L., Mgr., Marine Dept., International Steam Pump Co., New York

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BRAKE PERFORMANCE ON MODERN STEAM RAILROAD PASSENGER TRAINS

ABSTRACT OF RESULTS OF THE PENNSYLVANIA RAILROAD BRAKE TESTS, 1913

By S. W. DUDLEY[1], PITTSBURGH, PA.
Non-Member

Realizing the significance of the knowledge and experience accumulated in recent years, the Pennsylvania Railroad, in conjunction with the Westinghouse Air Brake Company, instituted in the spring of 1913 the most scientific and comprehensive investigation of the different factors affecting the operation of brakes on steam railroad passenger trains that has been undertaken since the Galton-Westinghouse trials of 1878 and 1879. In addition to an examination of the characteristics of brake shoe friction throughout a wide range of laboratory and operating conditions, the test included also a study of the effect of various types of air brake mechanisms and foundation brake rigging and different degrees of emergency braking force. The tests indicated the degree to which existing apparatus was suited to existing conditions, the direction in which improvement was necessary and could be made, and the amount of improvement actually accomplished.

A TRAIN of 12 steel passenger cars and modern locomotive weighs nearly 1000 tons, is about 1000 ft. long and, at 60 m.p.h. speed has a kinetic energy of 224,000,000 ft-lb.

With the ordinary high-speed brake apparatus such a train would be stopped by an emergency application of the brakes in a distance of from 1600 to 1800 ft., according to the truck rigging and brake shoe design and installation.

In making ordinary brake applications for slow-downs or station stops, skill and judgment must be carefully exercised in order to avoid shocks and make short and accurate stops.

The Pennsylvania Railroad brake tests of 1913 showed that such a train at 60 m.p.h. speed can be stopped by an emergency application in 1000 ft. or within the length of the train. They also showed that trains can be controlled by service applications without shocks at any speeds and with greater accuracy and promptness and still require less expert knowledge and skill on the part of the manipulator.

The improvement in emergency stopping power has resulted from applying the air brakes more quickly and to a higher pressure, holding this higher pressure without diminution toward the end of the stop, using a more efficient design and better installation of foundation brake rigging and providing a better method of applying the brake shoe to the wheel and more brake shoe metal to absorb the heat developed during the process of stopping.

The greater efficiency, economy and flexibility in service has been attained by making the air brake apparatus more positive and responsive in its operation, both in application and release, enabling full advantage to be taken of all the possibilities of these improvements through the quick, simultaneous and flexible action obtainable only with electric control, the maintenance of a high and uniform brake rigging efficiency, and the improved truck, journal and brake shoe action, less wear of brake shoes and better distribution of forces and reactions accompanying the use of the clasp brake having two shoes per wheel, instead of concentrating the heavy braking forces required by modern equipment on only one side of the wheel.

The tests constitute a scientific study of the brake as a whole; comparing in detail the characteristics of the ordinary high-speed air brake apparatus with the improved electro-pneumatic brake, the effect of low and high emergency braking powers, the clasp with the single shoe type of brake rigging, the relative advantages of one and of two brake shoes per wheel and investigating the limitations of track and operating conditions commonly experienced.

The improved air brake apparatus operating pneumatically, shortens the time of obtaining maximum emergency brake cylinder pressure on the train as a whole from 8 seconds, with the PM equipment, to 3.5 seconds, and with electric control this is again shortened to 2.25 seconds. Moreover, 125 per cent, 150 per cent or 180 per cent emergency braking power is available as may be thought desirable or found permissible according to circumstances when the installation is made. The PM average is 100 per cent.

Using 150 per cent emergency braking power, the quicker and more powerful pneumatic emergency application shortened the stop at 60 m.p.h. from over 1600 ft. to about 1400 ft. and the simultaneous action of the electro-pneumatic brake still further shortened the stop to less than 1200 ft.

With the PM equipment the attempt to make an emergency application during the progress of or before releasing a partial or full service application will produce only the same stop as if merely a full service application had been made. Considering the ordinary full service stop from 60 m.p.h. (say 2000 or 2200 ft.) as 100 per cent; with the improved apparatus, operating pneumatically, an emergency application following a partial service application will shorten about 14 per cent and after a full service application about 10 per cent; with electro-pneumatic operation the gain is 23 and 15 per cent respectively.

Shocks during brake applications are due to slack action modified by speed. This was shown by pneumatic and electro-pneumatic stops from both high and low speeds. At high speeds, 60 to 80 m.p.h., the serial action of the pneumatic emergency application resulted in noticeable shocks which increased in severity at lower speeds and at 10 m.p.h. amounted, in effect, to a collision between the rear and forward end of the train, the train being stopped in 42 ft. The simultaneous application of just as great retarding forces by the electro-pneumatic brake entirely eliminated violent slack action at all speeds.

[1] Assistant Chief Engineer, Westinghouse Air Brake Co.

I. THE BRAKE PROBLEM

The object of the Pennsylvania Railroad Tests of 1913 was to make as thorough a study as might be found practicable of the variables encountered in braking equipment, and their effects, with particular reference to:

A A determination of the maximum percentage of emergency braking power which can be adopted, considering:

- *a* The type of brake shoe to be used
- *b* The type of brake rigging to be adopted
- *c* The type of air brake mechanism and control to be adopted
- *d* The degree to which occasional wheel sliding is to be permitted under favorable circumstances
- *e* The variation in the condition of the rail surface for which it is considered necessary to provide

B A comparison of the relative performance of the clasp brake rigging (two shoes per wheel) and the standard brake rigging (one shoe per wheel) with regard to:

- *a* Maintenance of predetermined and desired piston travel
- *b* Efficiency of transmission of forces
- *c* Effect upon wheel journals, bearings and truck
- *d* Mean coefficient of brake shoe friction for the standard plain cast iron shoe

C A comparison of the performance of the improved air brake mechanism (type UC) with that of the commonly used "high speed" (type PM) brake equipment with regard to:

- *a* Efficiency and effectiveness, as shown by the length of service and emergency stops
- *b* Safety and protective features
- *c* Flexibility and certainty of response to any manipulation of the engineer's brake valve
- *d* Uniformity of action of individual equipments associated in the same train and of any individual equipment at different times
- *e* Smoothness of riding during stopping, slack action between cars, and the resulting shocks
- *f* Capacity for future requirements

D The behavior of the brake shoes as the tests progressed and any variation in the results of similar tests which could not be accounted for by known changes independent of the brake shoe. One type of brake shoe was to be used throughout the range of the tests. Relating to objects *A*, *B*, and *C*, advantage was taken of this opportunity to establish as definitely as possible the characteristics of this type of brake shoe under the influence of various combinations of speed, pressure, time, weather and the conditions of the brake shoe.

E The coefficient of friction between the wheel and the rail under varying weather conditions.

In addition to the investigations outlined in general above, it developed during the tests that additional data were desired regarding the performance of brake shoes under certain specific conditions. In consequence a series of experiments was carried out at the laboratory of the American Brake Shoe and Foundry Company, at Mahwah, N. J.

FEATURES OF EQUIPMENT AND APPARATUS TESTED

Air Brake. Experience has shown that under the severe requirements of today the type PM equipment lacks many of the features necessary to obtain a desirable degree of stopping power in emergency applications and prompt and certain response at all times in ordinary service brake manipulation. One of the objects of the tests scheduled for this type of equipment was to determine its limitations and serve as a standard of reference to measure the betterment made possible by the improved features of the new air brake apparatus, the more efficient design of foundation brake rigging and more satisfactory brake shoe performance.

The special features of the improved air brake equipment (type UC) which received more or less attention during the tests may be summarized as follows:

A Adaptability of the electro-pneumatic brake equipment to meet any requirement, with a degree of efficiency as high as the existing physical conditions will permit.

B Possibility of installation to produce any desired cylinder pressure, either in service or in emergency.

C Gain by use of the electric control, in addition to the pneumatic, in the elimination of the time required for the transmission of the action of the brake from car to car and, in addition the elimination of shocks and uncomfortable surging which results from the non-simultaneous application of the brakes on all cars.

D Troubles due to brakes failing to release, as well as the undesired application of brakes due to unavoidable fluctuations of brake pipe pressure when running over the road.

E Adequate supply of air available at all times.

F Emergency braking power available at any time, even after a full service application of the brake.

G Adaptability of the equipment to all weights of cars and to any desired percentage of braking power, eliminating necessity of two brake equipments for heavy cars or two service brake cylinders, except for cars weighing more than the limit of the service capacity of one brake cylinder.

Brake Rigging. Duplicate tests were made with the clasp brake rigging, two shoes per wheel, for every test made with the standard brake rigging, one shoe per wheel, in order to bring out the advantages of the clasp brake in the following desirable features: (*A*)

Abstract of paper presented at the New York local meeting of The American Society of Mechanical Engineers, on February 10, 1914. Complete copies may be obtained, price, 60 cents to members and $1.20 to non-members.

constant piston travel for all cylinder pressures; (*B*) smoothness of action during stopping; (*C*) greater certainty of obtaining and maintaining the predetermined braking force contemplated in the design of the air brake equipment and foundation brake rigging; (*D*) less displacement of journals, bearings and trucks, tending toward greater mechanical efficiency and less cost of maintenance; (*E*) a coefficient of friction equal to or greater than that with the single shoe brake, with less wear of brake shoe metal and lower brake shoe temperatures.

TRAIN MAKE-UP AND EQUIPMENT

The test train was 1040 ft. long, consisting of a Pacific type locomotive and tender of the P. R. R. K2s class, weighing in working order about 200 tons, and 12 P-70 steel passenger cars averaging about 61 tons each. These cars have 4 wheel trucks with one 16 in. brake cylinder per car.

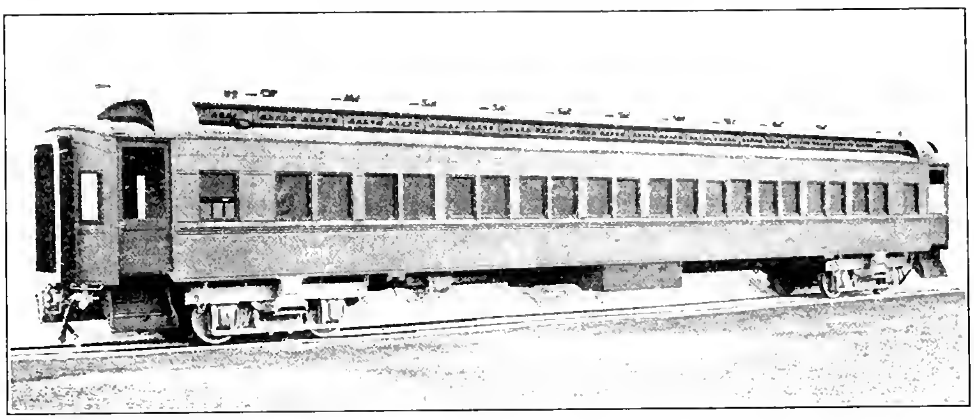


FIG. 1 CLASS P-70 STEEL CAR—TWELVE OF THIS TYPE USED IN THE TEST TRAIN

The ET air brake equipment was used without any modification on the locomotive, except that in some tests an auxiliary device was used which increased the braking power obtained during the early portion of the stop.

All tests were made under road service conditions, except where otherwise noted, the air brake regulating devices on the locomotive and cars being adjusted as follows: Pump governor, low-pressure head 130 lb. maximum pressure head 140 lb., feed valve, 110 lb., and ET distributing valve safety valve, 68 lb.

The cars were equipped with the present standard air brake apparatus (PM) and with the improved type of air brake equipment (UC), these installations being so arranged that a complete change from the standard equipment (PM) to the new equipment (UC) having PM features only or the complete pneumatic features of the new equipment or to the new equipment with complete electrical control could be quickly made.

The standard brake rigging as originally applied to the cars of the test train is shown in Fig. 3. With the No. 3 design of clasp brake rigging shown in Fig. 4 the best stops were made, fulfilling what it was anticipated should be obtained from the application of two brake shoes per wheel. The No. 3 clasp brake rigging was used only in single car break-away stops, there being but one car equipped with this type. Diagrams of the lever arrangement of the various types of brake rigging tested are shown in Fig. 5.

The standard plain cast-iron brake shoe was used in most of the tests. In several tests flanged, slotted and half area shoes were employed. Special care was taken to insure uniformity in quality and condition of all shoes at the beginning and during the progress of the tests.

The high-speed reducing valves of the PM equipment were adjusted to open at 62 lb. brake cylinder pressure. The standing piston travel was adjusted before each run to 6½ in. with a full service brake application.

TEST APPARATUS AND OBSERVATIONS TAKEN

Locomotive. The apparatus on the locomotive consisted of the usual gages which indicated main reservoir, brake pipe, and brake cylinder pressures, and in addition a brake cylinder indicator was used on the tender brake cylinder and served to measure the pressure in all of the brake cylinders of the locomotive and tender, viz., one engine truck, two driver brake, one trailer truck and one tender brake cylinder. A voltmeter, calibrated in m.p.h. was connected to a generator, belt-driven from the right front engine truck wheel, and served as a guide to the engineman in obtaining the desired speed.

A device for recording automatically the distance traveled by the train beyond the point of brake application was driven from the left engine truck wheel and was used in connection with the wheel sliding indicators on the cars.

Devices similar to those used in former brake tests were employed to operate the track circuit breakers and to automatically apply the brakes at the zero circuit breaker.

On the locomotive, observations were taken of the

time of stop and the main reservoir and brake pipe pressure, the tender piston travel and the amount of coal and water on the tender.

Cars. Each car was furnished with a brake cylinder indicator, and a wheel sliding indicator, with the necessary wiring and connections.

A chronograph, recording the distance of stop, time of stop, deceleration of train, the brake cylinder pressure and the brake pipe pressure, was located on car six. In connection with this chronograph a record was made of the action of the brake shoes with respect to sparking.

Indicators for measuring the slack action between the cars were used at different points in the train.

Specially designed apparatus was used to measure the pressure delivered to the brake shoes during some of the tests, the object of which was to determine the efficiency of the brake rigging.

After each test measurements were taken of the total length of the stop, and also the running piston travel on each car.

Rail Friction Machine. Of the devices used on the track, the only one which requires special mention is the machine for measuring the force required to move or keep moving a block of tire steel resting upon the rail. The pressure of this block on the rail could be varied by means of weights of 20, 40, 60, 80 and 100 lb. Readings were taken with each of these weights and the coefficient of rail friction recorded was derived from the average of the five readings.

When making a test run the engineman endeavored to reach a speed slightly above that desired, just before entering the measured track. The throttle was closed just before reaching the circuit breakers preceding the zero point, no change being made in the position of the reverse lever. The train then drifted over the

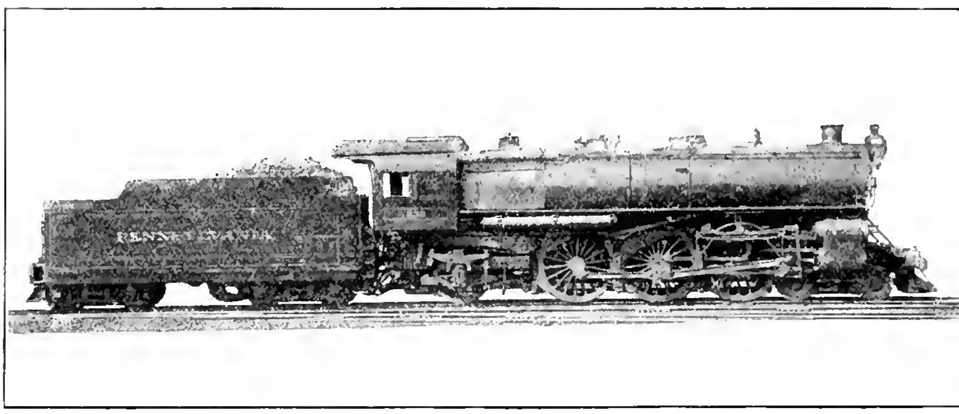


FIG. 2 CLASS K2sa LOCOMOTIVE—USED IN THE TEST TRAIN

Telephones were located in the first, third, sixth, ninth and twelfth cars and greatly facilitated the issuing of instructions.

Track. The tests were made on the south bound track of the Atlantic City Division of the W. J. & S. R.R. The portion of the track over which the braking was done was level, and part of a tangent about 25 miles long terminating at Absecon Station. A slight descending (0.3 per cent) grade approaching the measured test track was in favor of the train attaining speed.

The track for a distance of 5000 ft. south of the zero point was wired for circuit breakers, which were placed at intervals of 25 ft. up to 1200 ft. from the zero point, and at intervals of 50 ft. from there on to the 5000 ft. point. Preceding the zero point, eight circuit breakers were located, 66 ft. apart from which the initial speed of train (speed at the trip) was determined.

A cabin, located near the zero circuit breaker, contained the clock and chronograph from which in connection with the track circuit breakers, the speed of the train before and during the stop was obtained.

circuit breakers preceding the zero point at which point the brake was automatically applied by the trip mechanism. At the instant the brake pipe exhaust started at the trip, the brake valve handle was moved to emergency position for all emergency tests and to lap position for all service application stops. When the engine and cars were to be stopped separately (breakaway tests), the same procedure as above was followed, except that the coupling pin between the engine and tender was pulled out as soon as possible after steam was shut off. This permitted the engine to pull away from the train as soon as the brake application was made, providing the retardation of the cars was higher than that of the locomotive.

However, the engine did not always separate from the train when making stops with low braking powers on the cars. On this account it was decided to use steam on the locomotive in such tests as soon as the coupling pin was pulled out, so as to get the locomotive away from the cars and permit the cars to stop without any possible interference on the part of the locomotive, the stop of the locomotive in such cases being

disregarded. For such stops the flexible wiper and the tripping mechanism were on the first car instead of the locomotive.

In all 691 tests were made, at Absecon, in 91 days, covering a period of time from February 10 to May 22, 1913. These were divided with respect to the type of brake rigging equipment, whether standard single shoe or clasp Nos. 1, 2 or 3, and to form of brake shoe used, whether plain or flanged. The average day's work consisted in making from 10 to 12 runs, a maximum of 22 tests being made in one day.

II. AIR BRAKE EQUIPMENT

The quick action automatic brake (PM equipment), which is the present equipment on P.R.R. P-70 cars, is illustrated in Fig. 6. It comprises a 16-in. brake cylinder with automatic brake slack adjuster set for 8-in. running piston travel, a 16-in. by 42-in. auxiliary reservoir and a quick action triple valve, which controls the flow of compressed air:

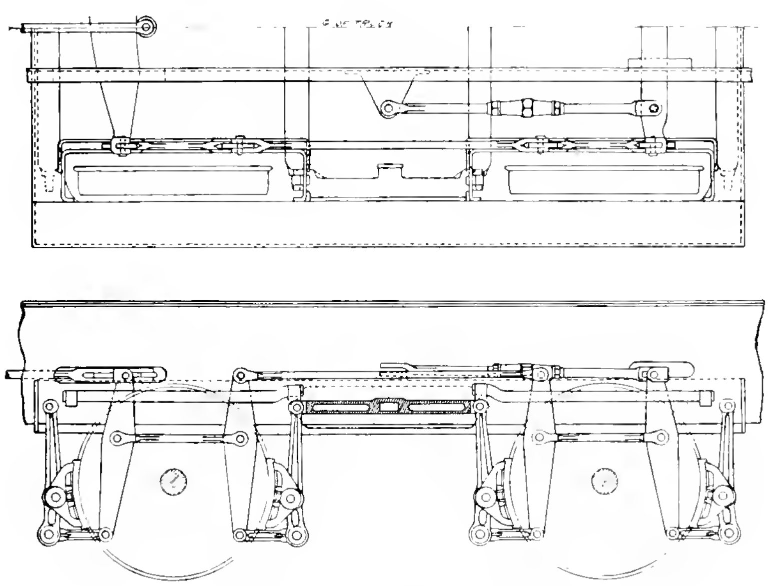


Fig. 4 The No. 3 Clasp Brake Rigging

a From the brake pipe to the auxiliary reservoir for charging the system.

b From the auxiliary reservoir to the brake cylinder for applying the brakes.

c From the brake cylinder to the atmosphere when releasing.

d From the brake pipe to the brake cylinder, as well as from the auxiliary reservoir to the brake cylinder, when a quick action application of the brakes is desired.

A high speed reducing valve designed to perform the functions of a safety valve during service brake applications, limits the brake cylinder pressure to a maximum, predetermined as satisfactory for service operations (62 lb.). In emergency applications the high speed reducing valve retains the maximum cylinder pressure practically constant for a period of time and then by an accelerating blow down, reduces the brake cylinder pressure to 60 lb. This reduction is designed to compensate for the increased effectiveness of the brake shoes as the speed diminishes. The compressed air required to charge the auxiliary reservoir is all supplied from the brake pipe through a feed groove around the triple valve piston when in release position only.

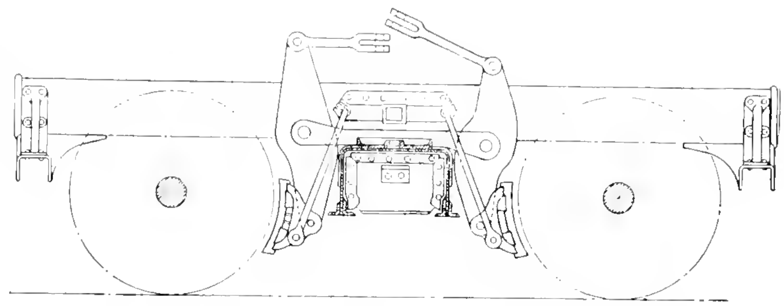


Fig. 3 The Standard Brake Rigging as Modified for Test

The certainty of releasing all brakes in the train depends on the possibility of establishing the differential pressure required to move the triple valve parts to release position. No difficulty is experienced in this direction so far as the cars at the head end of the train are concerned, but the increase in brake pipe pressure is necessarily slower at the rear than at the head end. Large auxiliary reservoir volumes, requiring a large amount of air for recharging (all of which must be drawn from the brake pipe), long trains, leaky brake pipe, poor condition of triple valve piston packing rings or slide valves, low main reservoir pressure, or light brake pipe reductions, all tend to bring about the slow rise of brake pipe pressure at the rear end of the train, which results in failure to release brakes, slow release, stuck brakes and dragging brake shoes.

The brake cylinder pressure in emergency is under the control of the high-speed reducing valve at all times. At first the reducing valve blows down the brake cylinder pressure at a very slow rate, but this rate gradually increases, being timed to become relatively rapid as the train nears its stopping point and the valve then closes at 60 lb. brake cylinder pressure.

It is impossible to obtain a quick action application with the PM equipment after a service application of any consequence has been made.

FEATURES OF THE UC EQUIPMENT

The valve mechanism which is the distinguishing feature of this equipment is of the "built-up" type which makes it possible to install and operate this

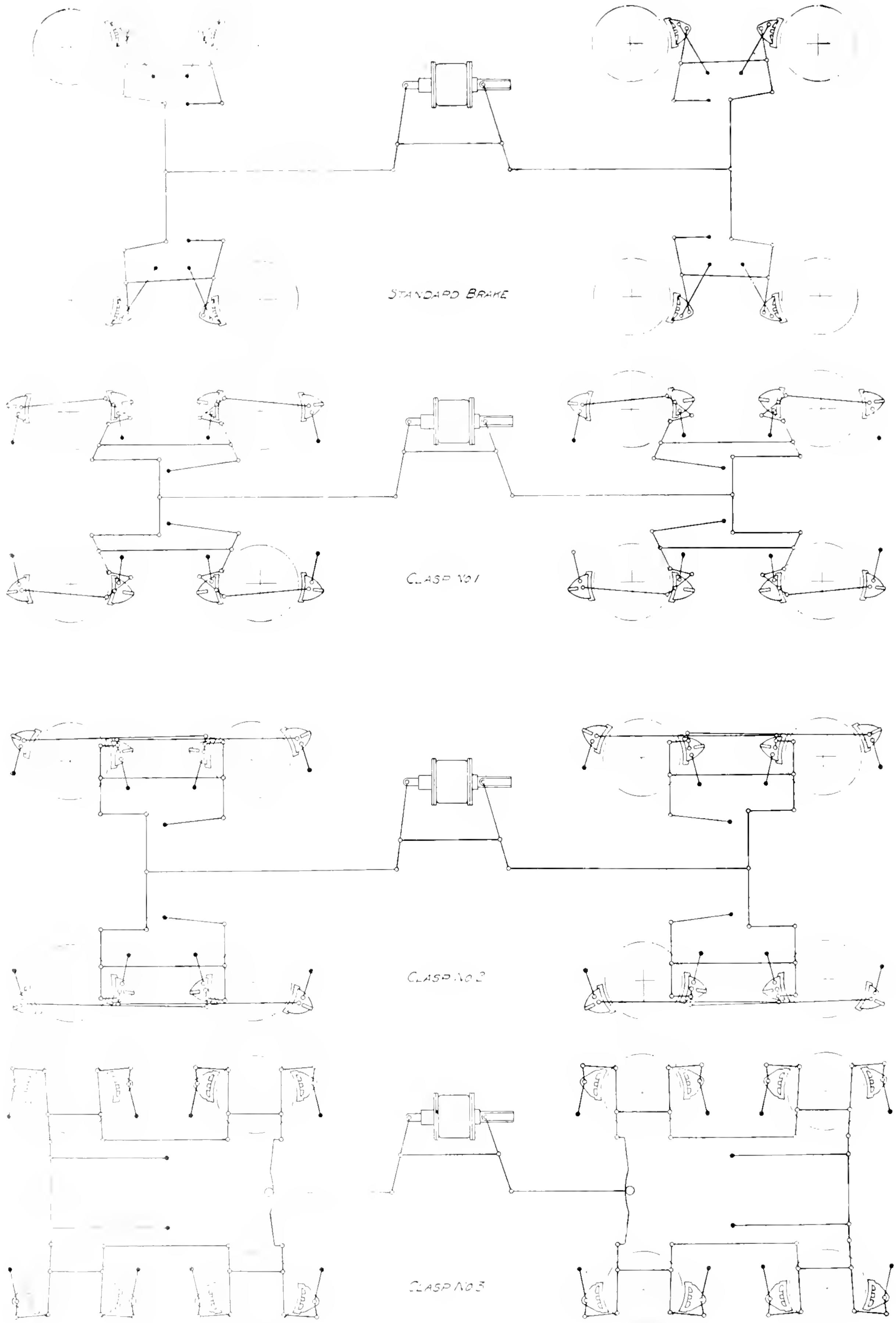


FIG. 5 OUTLINE DIAGRAM OF LEVER ARRANGEMENTS OF THE FOUR BRAKE RIGGINGS USED

equipment if desired in stages, by adding to the simplest arrangement of apparatus, including only those features required to give an operation equivalent to that of the PM brake, up to the complete form of the device.

The UC equipment, Figs. 7 and 8, in its complete form comprises a valve mechanism called the universal valve with its permanent pipe bracket and three reservoirs, the auxiliary, the service and emergency reservoirs.

The universal valve (Figs. 9 to 12), consists of an equalizing portion, which primarily controls the charging and recharging of the reservoirs of the equipment, the service application of the brakes and the releasing of the brakes.

A quick action portion with high pressure cap, which controls the transmission of serial quick action and obtaining of high emergency pressure in the brake cylinders when an emergency application of the brakes is made.

An electric portion, which comprises the magnets, switch, etc., controlling the electric service application, electric release and electric emergency applications of the brakes.

A pipe bracket, to which all pipe connections are permanently made and to which the various portions of the valve device are bolted. This bracket contains two small chambers, the quick action chamber and quick action closing chamber.

The *quick action closing chamber* provides means whereby the quick action outlet from the brake pipe to the atmosphere is open when an emergency application is made and is closed when a predetermined time thereafter has elapsed.

The *quick action chamber* in connection with the quick action closing chamber controls the operation of the quick action parts of the valve in accordance with the rate of brake pipe reduction.

In addition to the above the equipment on each car comprises:

An auxiliary reservoir which is the same size for all sizes of brake cylinders, the pressure in which controls the movement of the equalizing piston and slide valve of the universal valve and supplies air to the brake cylinder. The UC equipment has one size smaller auxiliary reservoirs than the PM equipment, being designed to give a brake cylinder pressure of 50 lb. per sq. in. when a 20 lb. brake pipe reduction is made; and furthermore, the braking power basis is 90 per cent instead of 80 per cent, as with the PM equipment.

A service reservoir which varies in size with the size of the brake cylinder. This, together with the auxiliary reservoir, supplies air for operating the brake cylinder in service and emergency brake applications.

An *emergency reservoir* which varies in size according to the size of brake cylinder used and the amount of emergency brake cylinder pressure which the installation is designed to afford. This reservoir supplies air required to graduate the release of the brakes and to obtain a quick recharging of the service and auxiliary reservoirs after a service application of the brakes. It also provides the additional supply of air required to obtain the increased brake cylinder pressure desired for emergency applications.

The valve mechanism is designed to require a drop in brake pipe pressure of approximately 4 lb. before it is possible to obtain an application of the brakes. The equalizing piston moves on a differential much lower than this, however, so as to close the feed groove and thus prevent back leakage from the auxiliary reservoir. Thus a service application of the brakes is positively insured when the required 4 lb. brake pipe reduction is reached. From this point the rise in brake cylinder pressure corresponds to the reduction in brake pipe pressure in the proper relation to produce a full service brake application (90 per cent braking power) for a brake pipe reduction of 24 lb.

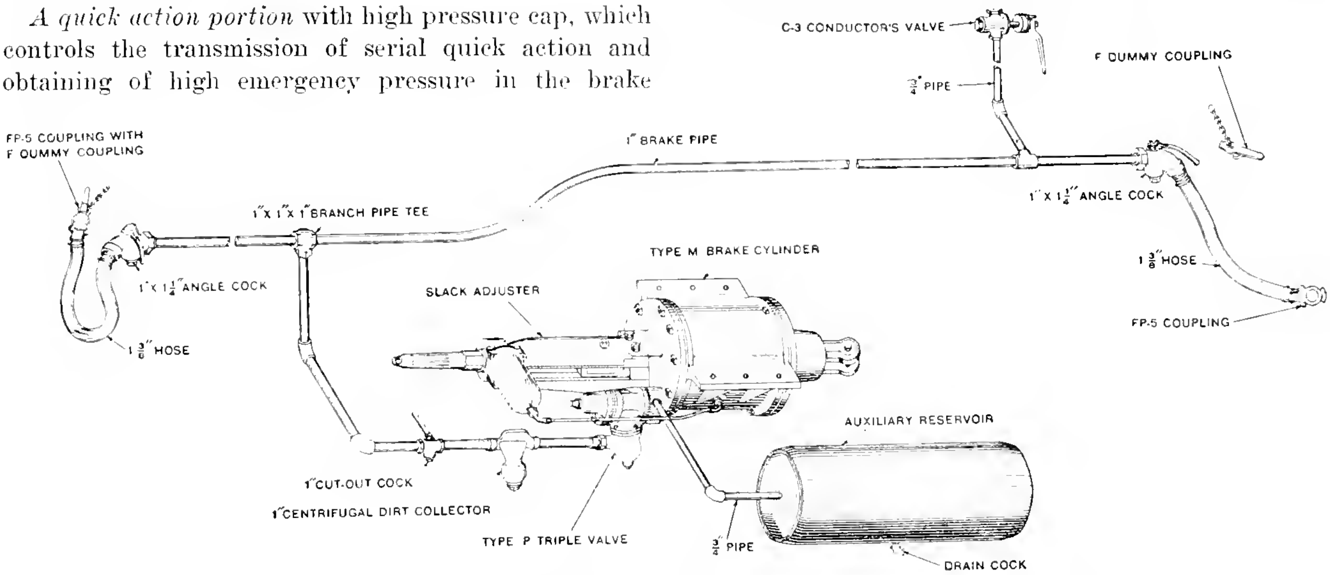


FIG. 6 ELEMENTS OF THE QUICK ACTION AUTOMATIC BRAKE (STANDARD PM EQUIPMENT)

The maximum brake cylinder pressure obtainable in a service application is limited by the setting of a quick blow-down and positive acting safety valve which is connected to the brake cylinder through the emergency portion of the universal valve at all times except when an emergency application of the brakes is made. When making an emergency application, the safety valve is automatically cut off from communication with the rest of the equipment. This safety valve is adjusted to limit the maximum obtainable service brake cylinder pressure to 60 lb. per sq. in.

EMERGENCY BRAKE APPLICATION AUTOMATIC ON DEPLETION OF BRAKE PIPE PRESSURE BELOW A PREDETERMINED POINT

Whenever, from any cause, the brake pipe pressure is reduced to a predetermined value (30 lb.), the protection valve included in the emergency portion of the universal valve will operate and cause the parts of the emergency portion to move to their quick action positions and so start a quick action application of the brakes—the operation of the equipment then being as already explained.

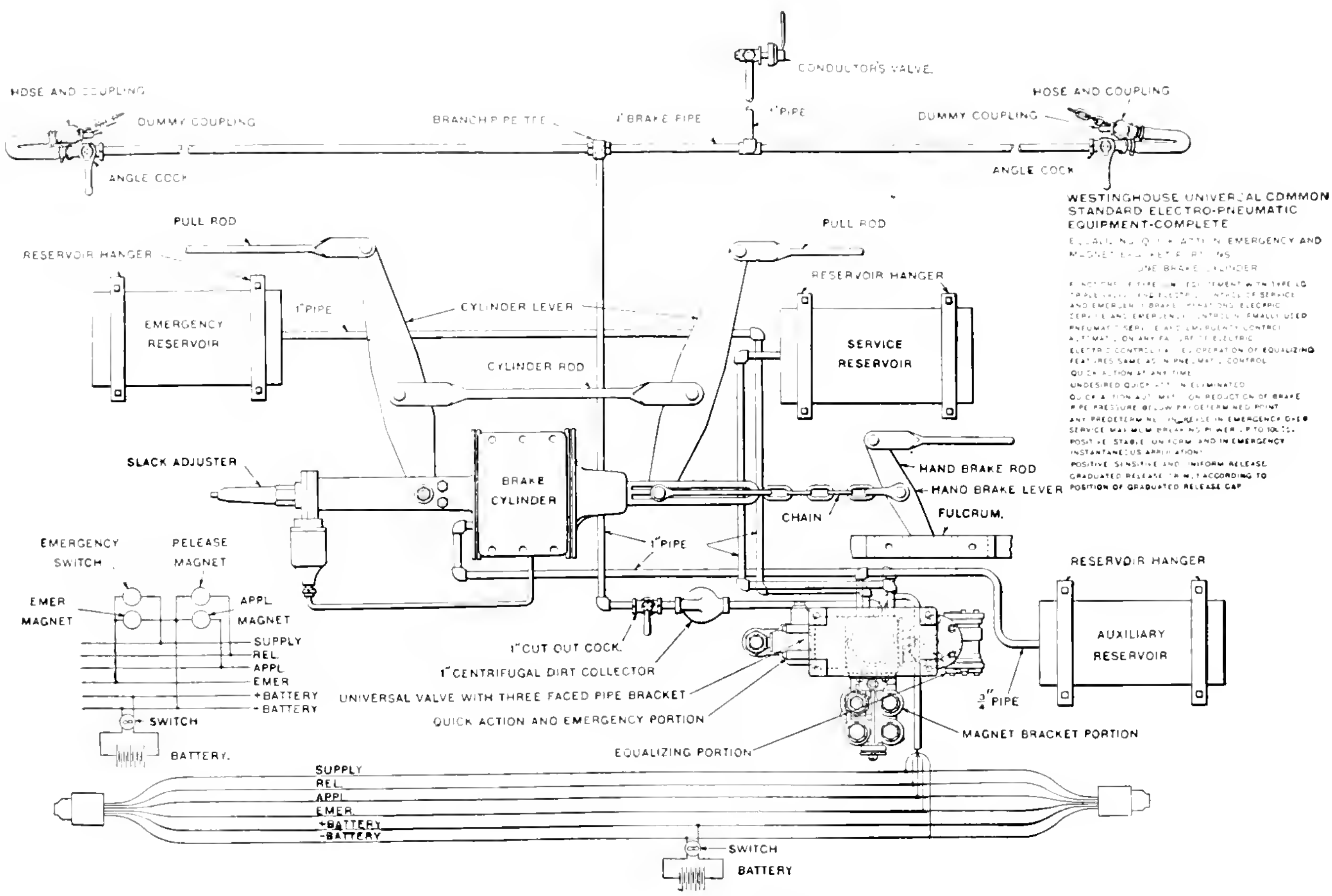


Fig. 7 Diagram of Elements of the Complete Electro-Pneumatic Brake and Connections (UC Equipment) for One Car

EMERGENCY BRAKE APPLICATION AFTER SERVICE BRAKE APPLICATION

Whenever a predetermined emergency rate of brake pipe reduction is established the quick action and high pressure parts of the valve will operate as above described to start serial quick action and increase the brake cylinder pressure up to its full emergency value even though a partial or full service brake application had been completed or was in progress. That is to say, the obtaining of an emergency application of the brakes depends only on the functioning of the quick action parts and is entirely independent of the service operation of the valve.

Within certain limits the percentage of emergency braking power and the brake pipe pressure to be used may be chosen as the conditions of operation and installation may dictate without requiring a change in any essential part of the apparatus and without affecting the fundamental and proper relations between the different reservoirs, cylinders and operating parts of the equipment. For example, one or two brake cylinders per car may be used as the weight of the car and the percentage of braking power desired may require, the only change necessary being the use of a special cap on the high pressure portion of the valve designed to handle two brake cylinders instead of one. The

amount of emergency braking power can be fixed to suit special limits or requirements by proper choice of reservoir volumes and the arrangement of their connections. The equipment is designed to give normally an emergency braking power of 150 per cent when using 110 lb. brake pipe pressure; this insures a satisfactory stop on the one hand without the likelihood of injurious wheel sliding on the other, with an average condition of foundation brake rigging, track, etc. For the transition period, or where conditions of installation do not permit, or where the service requirements do not necessitate a braking power as high as this, a lower emergency braking power is available by the arrangement of reservoirs mentioned.

FEATURES OF ELECTRIC OPERATION

When operating electrically, the service application of the brakes is actuated by a reduction in brake pipe pressure as when operating pneumatically. The equalizing portion of the universal valve causes the brakes to apply in response to a brake pipe reduction as when operating pneumatically. But this brake pipe reduction is made locally on each car (instead of all at one place, namely, the engineer's brake valve). This local reduction of brake pipe pressure is accomplished by means of the service magnet valves which open simultaneously on each car and vent brake pipe air to the atmosphere at the proper rate to produce a service brake application when the service magnets are energized by the engineer's brake valve handle being placed in service position. The fact that the pneumatic and electric service position of the brake valve handle are the same insures the elimination of any delay in starting a pneumatic application of the brakes in case the electric control is, for any reason, inoperative.

The movement of the brake valve handle back to lap position de-energizes the service magnets, which permits their valves to close and thus stop the brake pipe reduction. The valve parts then assume their lap positions as when operating pneumatically.

Electric Release. Whether the graduated release cap is in direct or graduated release position, the release of the brakes can always be graduated electrically by alternately energizing and de-energizing the release magnets which control the flow of air from the brake cylinder exhaust ports to the atmosphere. These release magnets are energized and prevent the release of the brakes when the brake valve handle is in either release or holding position. At this time the brake pipe and reservoirs on the car are being recharged and the universal valve parts are in their release and charging positions. The outlet from the brake cylinder to the atmosphere is closed and the brakes cannot release so long as the release magnets are thus energized. The release magnets are de-energized and the exhaust of air from the brake cylinders permitted when the brake valve handle is in running position.

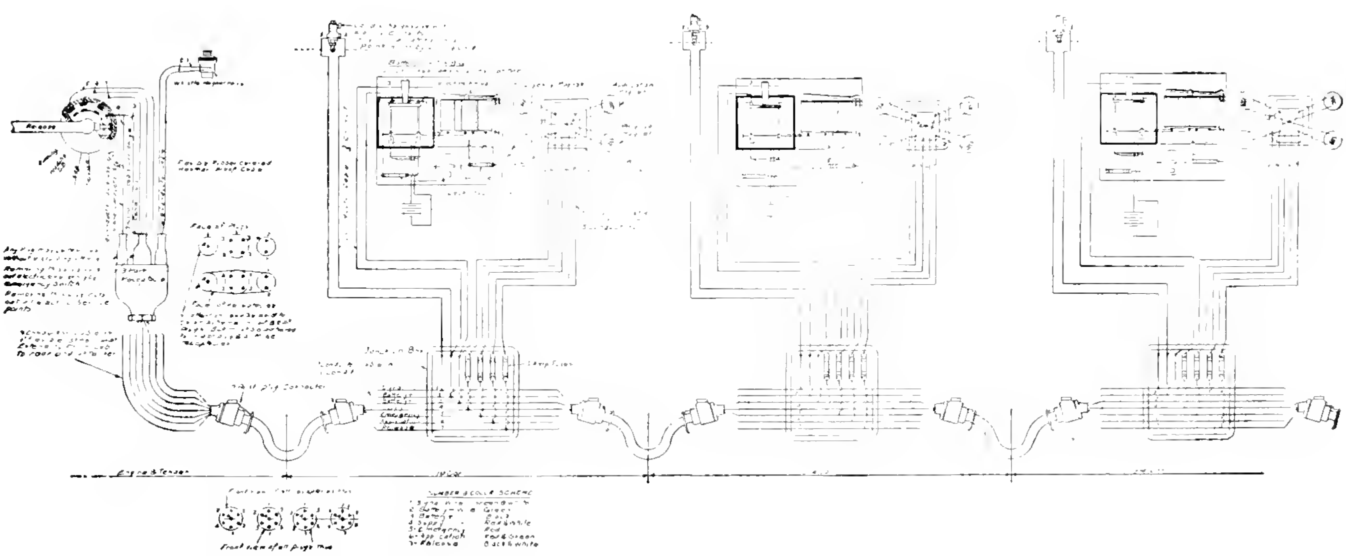


FIG. 8 DIAGRAM OF ELECTRIC CIRCUITS OF THE ELECTRO-PNEUMATIC BRAKE ON LOCOMOTIVE AND CARS (UC EQUIPMENT)

Electric Emergency. In an electro-pneumatic emergency application, the emergency magnets on all cars are simultaneously and instantaneously energized. These magnets open their respective emergency magnet valves which in turn cause the quick action parts of each universal valve to operate and produce an emergency application of the brakes. In case a hose bursts or a conductor's valve is opened, the first universal valve to be affected by the resulting drop in brake pipe pressure will operate pneumatically.

DEVICE FOR OBTAINING HIGHER BRAKE CYLINDER PRESSURE ON LOCOMOTIVE AND TENDER

As is well known, the standard braking power of the ET equipment on the locomotive and tender (considering the ordinary working loads carried) is relatively

a little less or about the same in stopping effectiveness as that of the PM equipment on the P-70 cars. With the new and more effective car brake equipments, however, there was a marked difference between the stopping force on the locomotive and cars. The effect of this was to produce a noticeable running out of slack in ordinary train stops and in breakaway stops to cause the locomotive to run several hundred feet farther than the cars. To avoid this a bypass valve was devised and applied in experimental form to the locomotive brake equipment. so arranged that the service operations of the ET equipment were not affected in any way, but when an emergency application of the brakes was made the bypass valve operated so as to short circuit compressed air directly from the main reservoirs to all the brake cylinders on the locomotive and tender. This resulted in a much quicker rate of rise of emergency brake cylinder pressure and a much higher maximum pressure being obtained than is the case with the standard ET brake. To protect against the drivers sliding, the by-pass valve was arranged to hold the high initial brake cylinder pressure for a specified period (about ten seconds) and then, by a gradually accelerating blowdown, reduce this pressure so that as the speed of the train diminished the brake cylinder pressure would finally reach the normal emergency pressure standard with this equipment, namely, about 75 lb.

FULL SERVICE BRAKE APPLICATION

Standard PM Brake Equipment. The action of the PM equipment during a service application of the brakes, is illustrated by the curves (Fig. 13). The cars at the head end of the train begin to apply and reach their maximum pressure before those at the rear of the train, which is true of any form of pneumatically controlled brake. The time of commencing to apply on different cars varies through a range of about four seconds, which is an indication of the relatively slow serial response of the brake mechanism to a gradual fall in brake pipe pressure controlled by pneumatic means alone. From these cards and similar cards for the UC pneumatic equipment (Fig. 14), it is easily seen that there is a considerable time element involved in starting the service application of all the brakes in

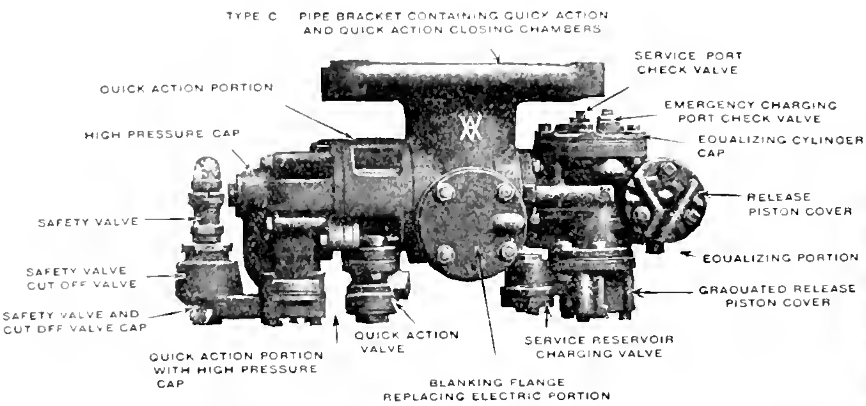


Fig. 9 Universal Valve, UC Equipment, Face View, without Electric Magnet Portion

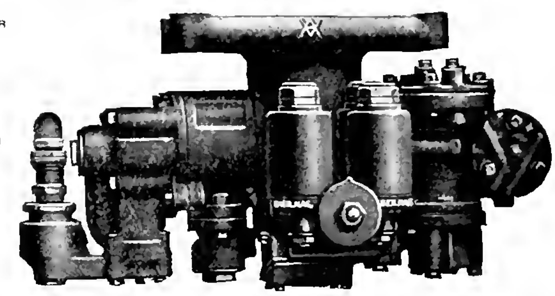


Fig. 10 Universal Valve with Electric Magnet Portion

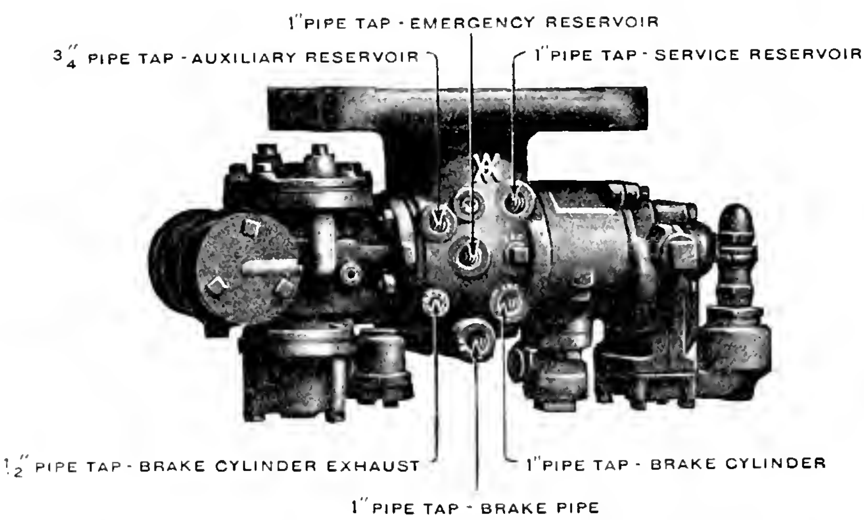


Fig. 11 Reverse Side of Universal Valve, UC Equipment, showing Pipe Connections

the train when operating pneumatically. It follows from this that the rate of " build-up " of brake cylinder pressure in a service application must be relatively slow in order to avoid shocks which result from the brakes applying with a slow serial action combined with too rapid " build-up " of pressure on the individual cars.

The total time required to reach maximum full service brake cylinder pressure is nearly 12 seconds, which shows clearly the effects of the long train (large brake pipe volume) in extending the time required to make a pneumatic full service brake application beyond a braking power of 80 per cent. The variations in the setting and the individual action of the different high-speed reducing valves is the cause of the varying degrees of maximum braking power obtained on the different cars.

UC Electro-Pneumatic Equipment. The advantages of the electro-pneumatic control of the service brake are apparent from a comparison of Fig. 15 with Fig. 14, which relates to the UC pneumatic equipment. With the electro-pneumatic brake (Fig. 15), the application started almost simultaneously on all cars and built up to maximum brake cylinder pressure at a

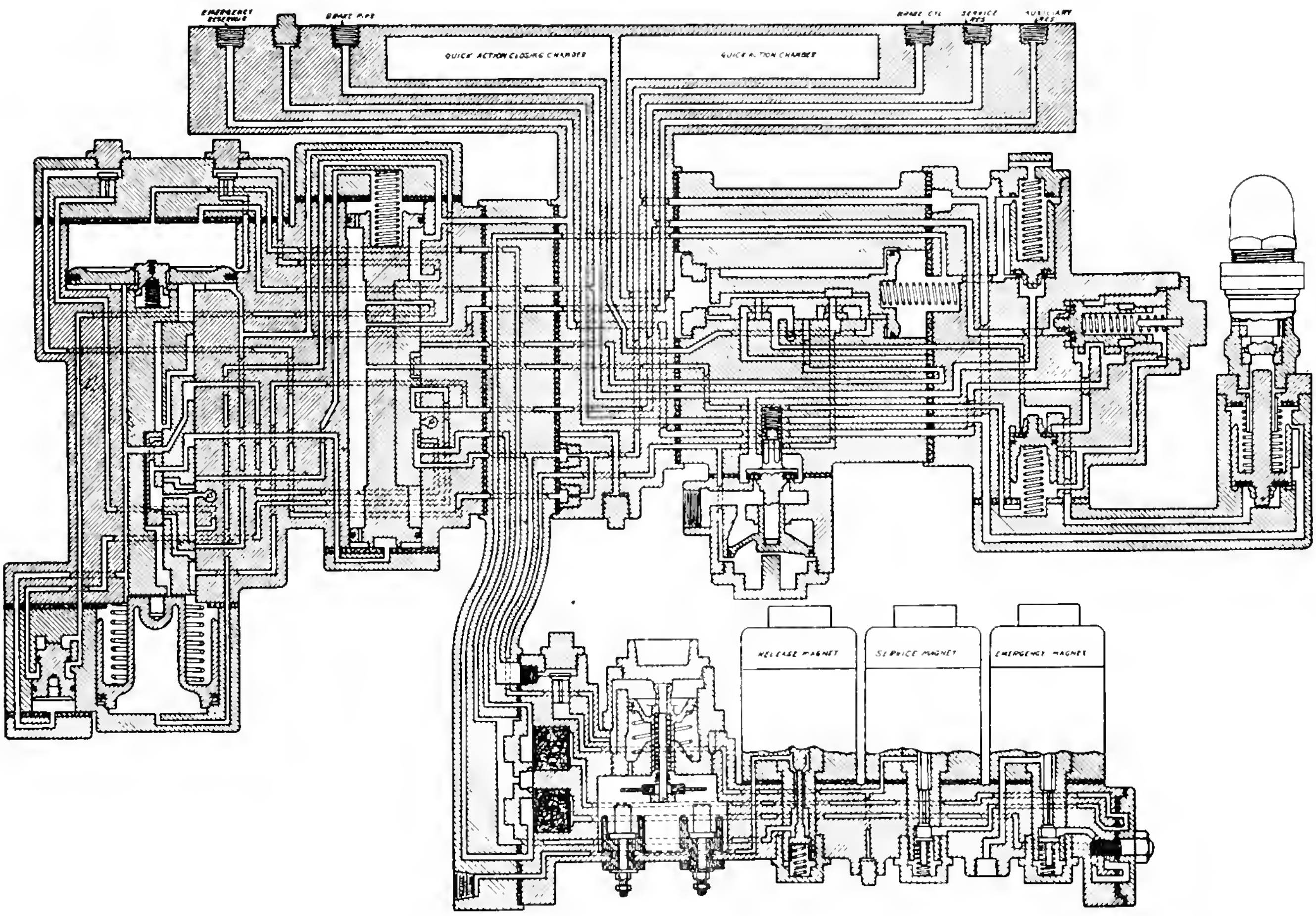


FIG. 12 DIAGRAMMATIC VIEW OF THE UNIVERSAL VALVE, UC EQUIPMENT, SHOWING SEQUENCE OF PARTS AND PASSAGEWAYS

minimum which is fixed by the design of the equalizing discharge feature of the brake valve; this requires that about 6 seconds at least be occupied in making a full service brake pipe reduction.

The rate of rise of brake cylinder pressure is more rapid than it would otherwise be, however, because of the use of the larger size auxiliary reservoirs with the PM equipments. For a given brake pipe reduction this results in a higher brake cylinder pressure than is obtained with a smaller size reservoir as used with the UC pneumatic equipment for the purpose of insuring flexibility of service operation of the brakes.

The maximum full service brake cylinder pressure is a trifle over 60 lb., which is equivalent to a nominal uniform rate. Furthermore, the rate of build-up of brake cylinder pressure is not dependent upon the length of train as it is in the case of any pneumatically controlled service application. The maximum service brake cylinder pressure is obtained in about 8 seconds instead of 16 seconds, required by the same brake equipment operating pneumatically.

PARTIAL SERVICE FOLLOWED BY EMERGENCY APPLICATION

PM Brake Equipment. Fig. 16 shows the results obtained with the PM equipment when a partial service brake application is made followed immediately by the movement of the brake valve handle from service to emergency position.

It is barely possible to distinguish signs of the emergency application from the shape of the curves when compared with a continuous full service application with this equipment without any emergency (Fig. 13). Slightly higher cylinder pressure was obtained on most of the cars sufficient to operate the high-speed reducing valves, but the rate of obtaining brake cylinder pressure is the same as if no emergency application had been made.

It should be noted that the serial action of the valves remains the same. There was no serial quick action effect produced by the emergency application following partial service application. The length of the stop, as would be expected, is but little different from that which was obtained with a full service application of the brakes, without any emergency application.

UC Pneumatic Equipment. In the case of the UC pneumatic equipment an emergency application produces serial quick action and full emergency brake cylinder pressure, whether preceded by a service application or not, Fig. 17. Consequently, when the emergency application was made all the brakes applied simultaneously, the brake cylinder pressure rose at the usual emergency rate and the usual emergency maximum cylinder pressure was obtained. The result of this is to shorten the stop by about 300 ft. compared with that obtained with a full service application.

UC Electro-Pneumatic Equipment. The action of the electro-pneumatic equipment (Fig. 18) is similar to that just described (Fig. 17), except that the time element due to the serial pneumatic application, both service and emergency, is eliminated, and the quicker rate of rise of brake cylinder pressure during the service application, which is due to the local venting of air from the brake pipe on each car, is produced by the electro-pneumatic service application feature. Both the service and the emergency applications occur on all cars simultaneously and the brake cylinder pressure rises as promptly on each car of a twelve car train as it would on a single car.

A direct result of the quicker rate of brake pipe reduction is that the partial service reduction determined upon is completed sooner and therefore the emergency application is made earlier in the stop than with the pneumatic equipment.

The result of these several advantages is to produce a much shorter stop (about 500 ft., Fig. 25) than with a full service electro-pneumatic application. This shows clearly the increased safety factor of the improved brake equipment over that now in service for conditions requiring the greatest possible stopping power after a service application of the brakes has been started.

EMERGENCY APPLICATION

PM Equipment. Fig. 19 shows characteristic brake cylinder indicator cards for PM equipment emergency applications. The rate of rise of brake cylinder pressure is slightly faster and the maximum pressure obtained slightly higher than would ordinarily be the case on account of the larger size of auxiliary reservoirs used.

The characteristic blow-down action of the high-speed reducing valve is clearly shown by the shape of the curves. The cylinder pressure is reduced from an average of about 78 lb. at the beginning to nearly 60 lb. at the end of the stop.

UC Pneumatic Equipment. Fig. 20 shows characteristic brake cylinder pressure cards obtained with this equipment, emergency application. The brake cylinder pressure rises almost instantly to its maximum value and is held without blow-down throughout the stop, thus utilizing the air pressure available on each car to its fullest extent and effect. The results to be expected from this quick rise of brake cylinder pressure are offset to a certain extent, however, by the relatively slow rate of transmission of serial quick action which resulted in the stop being somewhat longer and not as smooth as would have been the case otherwise.

The brake cylinder indicator cards (Fig. 20), show that the time of transmission of serial quick action was slightly longer than with the PM equipment. This was due to operation of the valve mechanism, and it was found possible to quicken the pneumatic serial quick action feature without any material change in the design of the parts.

UC Electro-Pneumatic Equipment. With the electro-pneumatic equipment a simultaneous and almost instantaneous application of the brakes in the train is obtained. The valve mechanism on each of the cars causes the brake cylinder pressure to rise to its maximum as quickly as the physical limitations of the air brake and foundation brake gear installation as a whole will permit and the maximum cylinder pressure thus obtained is maintained without blow-down (Fig. 22).

It should be noted that the only difference between the UC pneumatic and electro-pneumatic emergency applications is in the elimination of the time element in starting the application of the brakes on the various cars in the train. That this is an important gain, is shown by the fact that the emergency stops with the electro-pneumatic brake were from 200 to 275 ft. shorter than with the pneumatic equipment. The electro-pneumatic emergency stops are from 350 to 550 ft. shorter than those obtained with an emergency application of the PM equipment and also are devoid of shocks.

GRADUATED RELEASE STATION STOP AT 45 MILES PER HOUR

UC Pneumatic Equipment. This test was made to illustrate the proper method of making a graduated release stop. The initial application was made with one continuous full service brake pipe reduction, was then held a few seconds after which the release was graduated by moving the brake valve handle from lap to

running position and then back to lap position, four distinct graduations being made. This resulted in the braking power being reduced substantially in accordance with the decrease in the speed of the train.

Except for the first three cars in the train, which felt the effects of a graduation of the release most promptly and consequently tended to release sooner than the cars toward the rear, the amount of brake cylinder pressure remaining when the train stopped was uniform throughout the train. This stop was very smooth from the beginning of the application until the train came to a standstill and the low cylinder pressure remaining at the end entirely eliminated the unpleasant surging usually experienced when the train comes to a stop with high pressure in the brake cylinders.

III. BRAKE RIGGING

The only trustworthy indication we have of the relative performance of different brake riggings is in the length of the stop produced. But the stop is a resultant of both brake shoe and brake rigging performance, other conditions remaining the same. During these tests no satisfactory separation of the brake rigging and brake shoe performance during the process of stopping was effected. Consequently, when the stops produced by clasp brake rigging are being compared with those made by a rigging having but one shoe per wheel it is important to keep in mind that the performance in each case is a resultant of both brake rigging and brake shoe characteristics.

The various designs of rigging tested were the standard brake single-shoe type and three types of clasp brake known as Nos. 1, 2 and 3, respectively. The single-shoe brake used in these tests, shown in Fig. 3, had the strength of various rigging members increased to allow for the use of 180 per cent emergency braking power, the truck dead lever anchored to the car body center sill and the brake shoes hung about 4 in. below the horizontal center line of the wheel. The effect of the position of the brake shoes was to compress the truck springs during brake applications, causing horizontal movement of the brake shoes and a consequent increase in piston travel, which tended to reduce the effectiveness of the brake.

In the improved (No. 3) type of clasp brake, the members were so located that when the brake was applied, all the rods pulled perpendicularly to their respective levers and the pull rods rested on rollers, reducing the friction to a minimum. The shoes were hung as high as conditions would permit, being $2\frac{1}{2}$ in. below the center line of the axle, the brake heads were pin connected to the hanger levers, enabling the shoe to adjust itself readily to the wheel. All possible reduction was made in the sources of loss in the transmission of forces from the brake cylinder to the brake shoe.

TESTS MADE AND RESULTS

The standard (single shoe) brake rigging was tested under various conditions of speed, air brake equipment and braking power, using the complete train of 12 cars and locomotive, and also in 12 car breakaway stops. The clasp brake rigging was tested in single car breakaway tests only, there being but one of the test cars equipped with this type of rigging. Therefore, in comparing the different types of rigging it will be necessary to make the comparisons accordingly so far as the actual stops are concerned, although a method has been developed whereby the probable stop of a complete train can be computed with what is believed to be reasonable accuracy.

On account of the many different conditions of air brake equipment, per cent of braking power, and manipulation used with the different types of brake rigging, it is necessary to choose arbitrarily some representative combination of these factors and compare the different riggings all on the same basis. For this purpose the best available records are those of the so-called check runs, namely, emergency stops made at 60 m.p.h. with the complete train of 12 cars and locomotive using the electro-pneumatic air brake equipment and 150 per cent nominal braking power, and the breakaway stops under similar conditions.

TABLE 1 EMERGENCY STOPS 60 M.P.H. WITH ELECTRO-PNEUMATIC BRAKE, 150 PER CENT NOMINAL BRAKING POWER

Kind of Brake Rigging	Kind of Stop	Stop Distance in Ft.			Average Braking Power, Train	Per Cent Braking Power per Lb. Cylinder Pressure, Cars
		Average	Maximum	Minimum		
Standard.	Train.	1160	1298	1049	133	1.473
	12 car breakaway	1228	1291	1178	143	1.473
No. 1 clasp.	Train	1204	1273	1157	135	1.499
	12 car breakaway	1145	1183	1112	148	1.499
No. 2 clasp	Train.	1145	1213	1097	134	1.450
	12 car breakaway	1136	1178	1073	141	1.450
No. 2 clasp	Single car breakaway.	1014	1027	1007	140	1.430
No. 3 clasp.	Single car breakaway.	924	1010	873	149	1.505

Table 1 gives average results and in preparing it tests were not considered in which the stops were influenced by conditions other than the action of the brake rigging.

Inspection of the table shows that the per cent braking power varied somewhat from the different types of rigging tested. This variation, so far as the difference between train and breakaway is concerned, necessarily follows from the effect of the lower braked locomotive.

Comparing the braking powers for the train using the No. 1 clasp, the standard, and the No. 2 clasp brake and for the 12 car breakaway stops with these types of rigging it will be seen that the variation is not sufficient to materially affect the average results obtained.

The No. 3 design of clasp brake was tried on a single car only. Consequently its performance has to be compared with that of the No. 2 clasp brake on a single car. The braking power per pound of brake cylinder pressure for the No. 3 clasp brake was higher than that of the car having the No. 2 clasp brake as shown in the table and due allowance must be made for this, but after making due allowance, the stops with the No. 3 clasp brake are still materially shorter than corresponding stops with the No. 2 clasp brake.

To sum up, therefore, the relative performance of the several different types of rigging tested on the basis of stopping distance alone, would on the whole be arranged in the following order: Best, the No. 3 clasp brake; next, the two experimental designs of clasp brake, Nos. 1 and 2, and lastly the single shoe brake.

A device used to measure the efficiencies of the brake rigging tested consisted of a steel ball and plate of known hardness located in the brake rigging as near the shoe as possible so that the force transmitted by the brake rigging passed through the ball to the plate on its way to the brake shoe. The diameter of the impression was measured with a micrometer microscope and the corresponding pressure determined from a calibration curve of similar impressions made under direct known pressure on a testing machine.

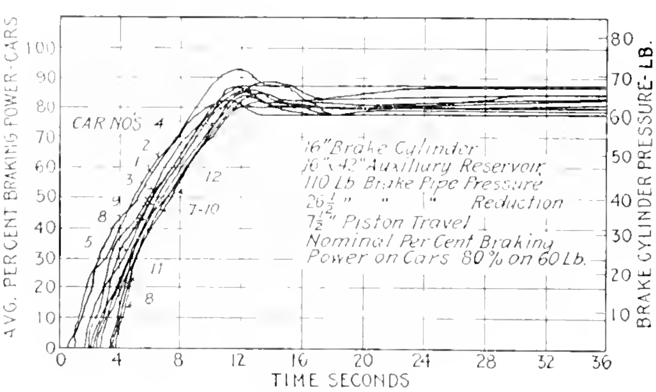


Fig. 13 Curves showing Rate of Building Up of Brake Cylinder Pressure in a Full Service Application, PM Equipment

The ratio of the pressure at the brake shoe as found by this method, to the brake shoe pressure which should result from the cylinder pressure and the total lever ratio known to exist, represents the mechanical efficiency of the rigging in per cent.

Tests of this character were made both when the cars were running and standing, but on account of the disturbing influences encountered during the running tests, it was decided to consider only the standing tests, for which the data obtained were more consistent. It should be understood, however, that the efficiency of the transmission of the forces through the brake rigging when making a stop was considerably different than when a standing brake application is made, due to the different positions assumed by the brake shoes and levers, caused by pulling down truck spring and increase of piston travel.

With the standard brake rigging considerable binding took place in the measuring device which affected the accuracy of the readings and is probably one of the causes of the low efficiency shown. With the other types of brake rigging, however, the results were remarkably consistent. In fact, by the aid of these records, it became possible for the first time to fix upon a logical basis for harmonizing the results obtained in road tests with those obtained in laboratory tests of brake shoes.

PISTON TRAVEL

One of the factors, affecting the brake rigging efficiency, which was given particular attention, was the variations in piston travel with different cylinder pressures. Records were taken of the length of piston travel on a time basis and of brake cylinder pressures and these records were combined to form the brake cylinder pressure piston travel curves.

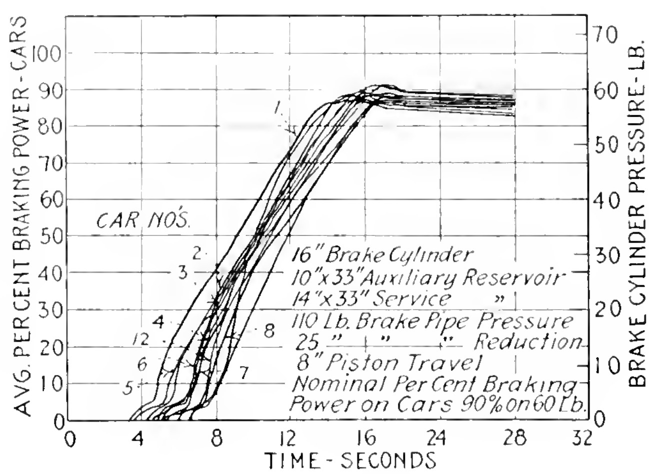


Fig. 14 Curves showing Rate of Building Up of Brake Cylinder Pressure in a Full Service Application, UC Pneumatic Equipment

Referring to the increase in running emergency piston travel over standing service for the different types of rigging tested and at various percentages of braking power, it is to be noted that the increase for the No. 1 and No. 3 clasp brake is less than for either the standard or the No. 2 clasp brake, due in part, at least, to the low hung brake shoes of the latter.

IV. PER CENT OF BRAKING POWER

Definition. The total brake shoe pressure to be provided by a steam road passenger brake installation is determined according to the empty weight of the car. For convenience the pressure afforded by a full service application of the brakes is chosen as the basis upon which different installations are classified and (also for convenience) the total brake shoe pressure is usually

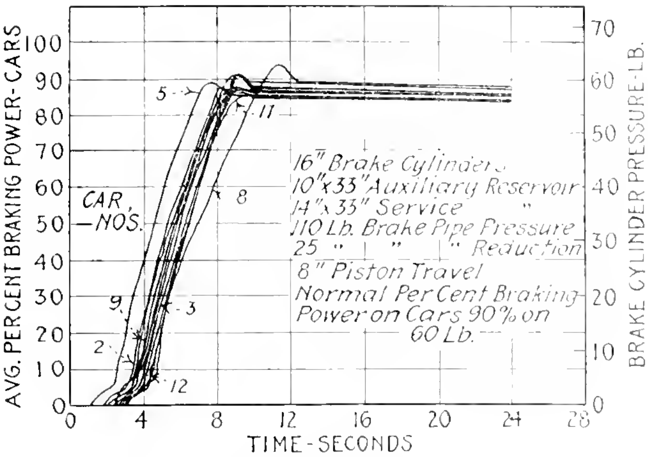


FIG. 15 CURVES SHOWING RATE OF BUILDING UP OF BRAKE CYLINDER PRESSURE IN A FULL SERVICE APPLICATION, UC ELECTRO-PNEUMATIC EQUIPMENT

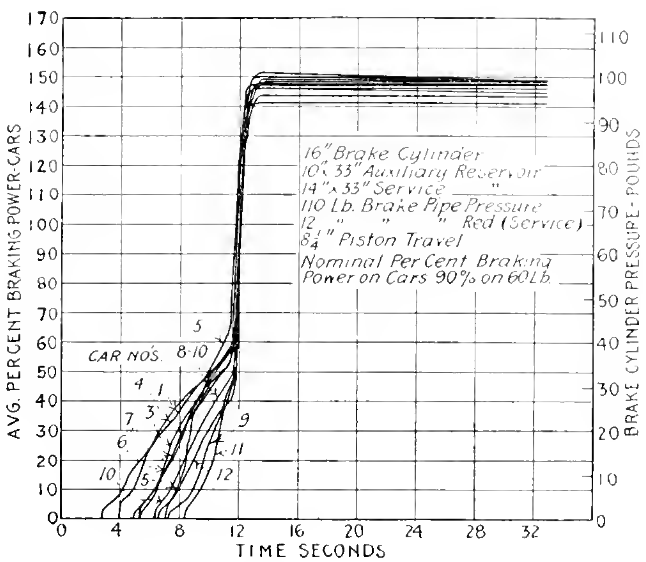


FIG. 17 CURVES SHOWING RATE OF BUILDING UP OF BRAKE CYLINDER PRESSURE IN A PARTIAL SERVICE FOLLOWED BY AN EMERGENCY APPLICATION, UC PNEUMATIC EQUIPMENT

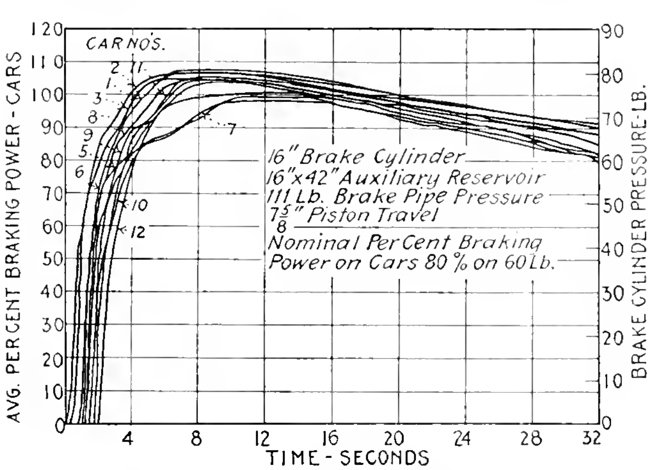


FIG. 19 CURVES SHOWING RATE OF BUILDING UP OF BRAKE CYLINDER PRESSURE IN AN EMERGENCY APPLICATION, PM EQUIPMENT

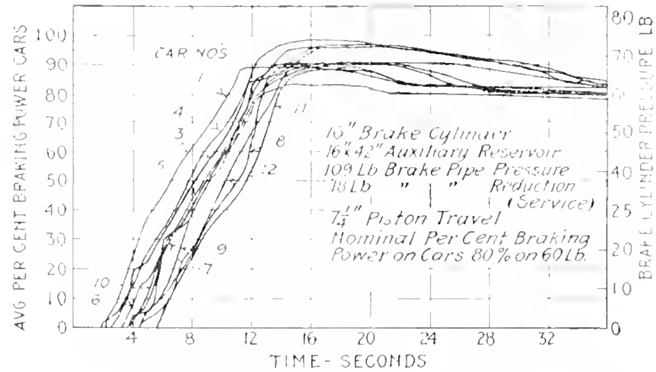


FIG. 16 CURVES SHOWING RATE OF BUILDING UP OF BRAKE CYLINDER PRESSURE IN A PARTIAL SERVICE FOLLOWED BY AN EMERGENCY APPLICATION, PM EQUIPMENT

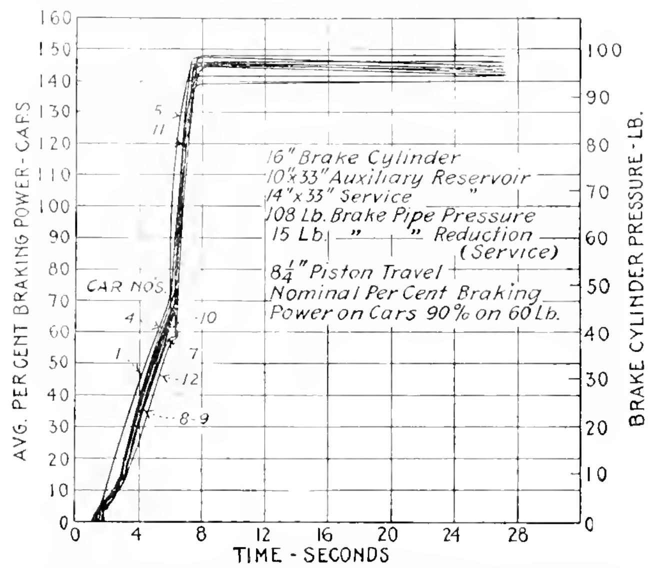


FIG. 18 CURVES SHOWING RATE OF BUILDING UP OF BRAKE CYLINDER PRESSURE IN A PARTIAL SERVICE FOLLOWED BY AN EMERGENCY APPLICATION, UC ELECTRO-PNEUMATIC EQUIPMENT

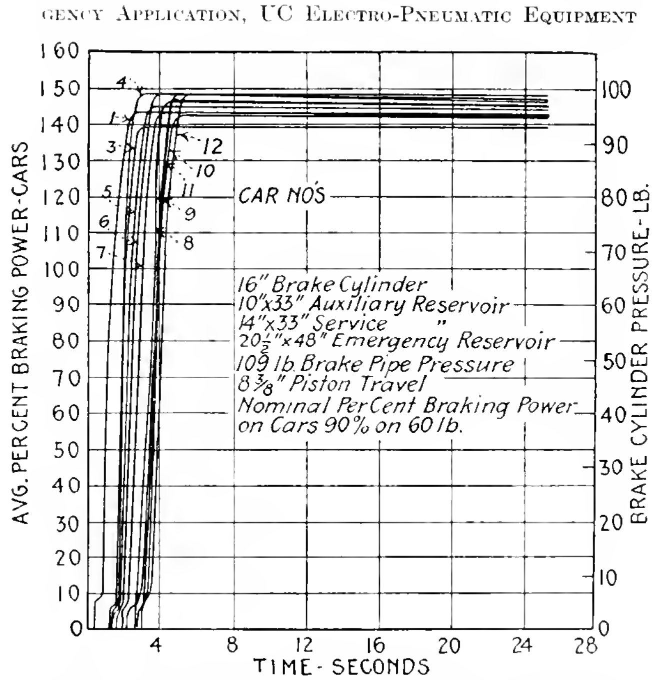


FIG. 20 CURVES SHOWING RATE OF BUILDING UP OF BRAKE CYLINDER PRESSURE IN AN EMERGENCY APPLICATION, UC PNEUMATIC EQUIPMENT

expressed in terms of its ratio to the empty weight of the car. The ratio of total brake shoe pressure to total car weight has always been termed "braking power" and is usually expressed as "per cent braking power."

It has been common practice to design steam road passenger brake installations to produce a full service nominal braking power of 80 or 90 per cent; the braking power obtained in emergency applications will then depend upon the characteristics of the installation. In the case of the P. R. R. P-70 cars with standard PM brake equipment the standard nominal braking power is 80 per cent. In emergency application nominal 113 per cent braking power is figured upon, but in practice less than this is always obtained, due to the characteristics of the PM equipment whereby the maximum brake cylinder pressure is diminished by the action of the high-speed reducing valve, the effect of excessive piston travel and so on.

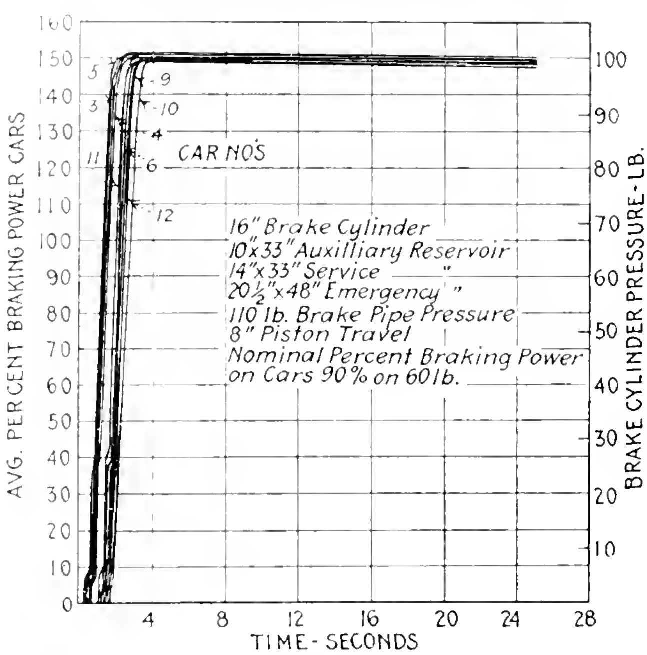


Fig. 21 Curves showing Rate of Building Up of Brake Cylinder Pressure in an Emergency Application with Improved Universal Valve, UC Pneumatic Equipment

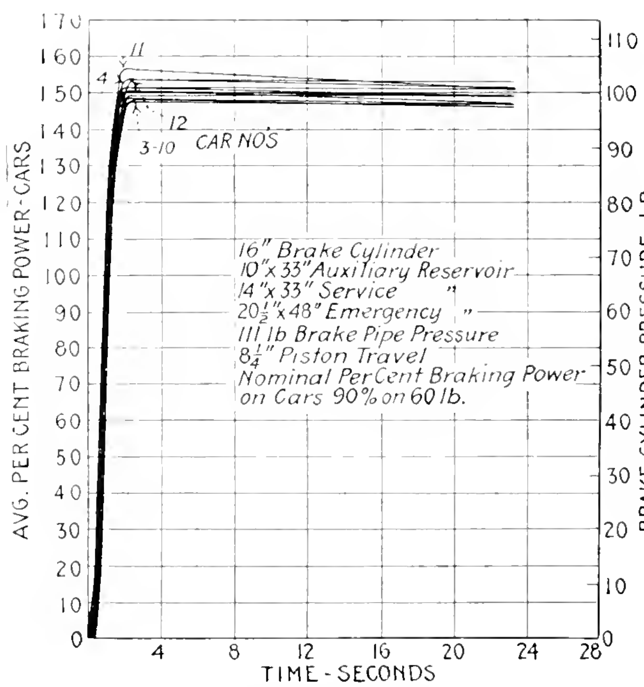


Fig. 22 Curves showing Rate of Building Up of Brake Cylinder Pressure in an Emergency Application, UC Electro-Pneumatic Equipment

With the improved brake equipment the standard nominal braking power is 90 per cent. This, although 10 per cent higher than standard with PM equipment, is associated with a smaller size auxiliary reservoir which results in a slower rate of increase in braking power during the progress of a service application of the brakes. This affords greater flexibility in the manipulation of the brake in service and at the same time makes available a higher maximum service braking power. In emergency stops braking powers ranging from 90 to 180 per cent were employed.

LENGTH OF STOP

The curves, Fig. 23, show the relation between the percentage of braking power and the length of stop, other factors being substantially constant. The curves are plotted for single-car breakaway stops from 60 m.p.h. with the No. 3 clasp brake, electro-pneumatic air brake equipment, plain brake shoes well worn in and cracked.

Taking from these curves the stop at 90 per cent as the basis, the stop at 125 per cent is 17.5 per cent shorter, that at 150 per cent braking power 25.5 per cent shorter, and that at 180 per cent 33 per cent shorter. An interesting development from this is that for a given increase in braking power anywhere throughout the range, a constant decrease in length of stop will result, this constant decrease, however, not being equal to the corresponding increase in braking power. For example, an increase of 25 per cent in braking power (from 90 up to 112.5 per cent braking power) results in a decrease of about 12 per cent in the length of stop (from 1177 ft. to 1033 ft.). Similarly, a 25 per cent increase in braking power, from 144 up to 180 per cent, results in the same proportionate decrease in length of stop, viz.: from 896 ft. to 787 ft., which is a 12 per cent decrease, as at the lower braking power.

An analysis of the curves on Fig. 23 shows that for single car breakaway stops from a speed of 60 m.p.h., using the electro-pneumatic brake, the relation between the percentage of braking power and length of stop can be expressed by the following equation:

$$S = \frac{K}{P^x}$$

in which S = the length of stop

K = a constant determined by the character of the air brake equipment, brake shoes and brake rigging.

P = percentage of braking power corresponding to the cylinder pressure obtained.

x = a fractional exponent, depending upon the effect of the percentage of braking power on the brake rigging efficiency and the coefficient of friction of the brake shoes.

This law is found to apply to both of the curves in Fig. 23 and that it holds for still lower braking powers than here shown was proven by both road and laboratory tests at low percentages of braking power (50 to 60 per cent), the results of which satisfied the relation which had previously been found to exist between stops under similar conditions, but at percentages of braking power ranging between 90 per cent and 180 per cent. Manifestly, however, this law could not hold at very low percentages of braking power.

Referring to Fig. 23 the equation for the line showing the best 60 m.p.h. stop is

$$S = \frac{1107.5}{P^{0.581}}$$

and for the line showing the average 60 miles per hour stops

$$S = \frac{1169.2}{P^{0.583}}$$

An approximate expression for the variation of percentage of braking power and length of stop with the electro-pneumatic equipment, is that, for an increase of 5 per cent in the braking power, the stop is decreased 2 per cent.

The above equations correspond to the theoretical relations which result from a consideration of the primary factors involved. Neglecting air and internal resistance on the one hand and the rotative energy of the wheels and axles on the other hand and considering the stop to be made on a straight level track, we have, for the portion of the stops that the brakes can be considered fully applied

$$FS_2 = \frac{1}{2}\frac{W}{g}v^2$$

$$PWefS_2 = \frac{Wv^2}{2g}$$

$$S_2 = \frac{v^2}{2gPef}$$

or

$$S_2 = \frac{0.0334V^2}{Pef} = \frac{V^2}{30Pef}$$

in which

F = total retarding force in lb.

S_2 = that portion of the stop in ft. during which the brakes can be considered fully applied

W = weight of train in lb.

v = speed of train in ft. per second

V = speed of train in miles per hour

P = nominal percentage of braking power corresponding to average brake cylinder pressure during time brakes are applied

e = efficiency of brake rigging

f = mean coefficient of brake shoe friction

g = acceleration due to gravity 32.2 ft. per sec. per sec.

For the short time t, at the commencement of the stop during which the brakes may be considered as having no effect, the distance traveled will be $S_1 = vt = 1.467\ Vt$.

The total length of stop S, is then

$$S = S_1 + S_2 = 1.467Vt + \frac{V^2}{30Pef}$$

For a given type of brake equipment and at a given speed, V and t are constants and the theoretical relation between the length of stop and percentage of braking power, other conditions being equal and as assumed above, is then

$$S = k + \frac{C}{Pef}$$

in which e, the efficiency of the brake rigging, remains practically constant throughout the range of values of P used in these tests. Let

$$\frac{C}{e} = C_1$$

f, the mean coefficient of friction, is known to decrease as P increases, other conditions being the same. It may therefore be assumed that

$$f = \frac{c}{P^z} = cP^{-z}$$

where z is less than unity.

The expression for length of stop can now be written

$$S = k + \frac{C_1}{PcP^{-z}} = k + \frac{M}{P^{1-z}} = k + \frac{M}{P^x} = \frac{M + kP^x}{P^x}$$

In this expression k is a constant term resulting from the fact that the brake applies gradually instead of instantaneously to its maximum value.

For practical purposes the formula

$$S = \frac{K}{P^x}$$

can be used as substantially the equivalent of more accurate but less simple formula, provided that the proper value of K is determined. This can be shown from the test data to be possible without involving an error of more than 2 per cent at the extremes of the range of these experiments, the error being still less at intermediate points.

In the relation $f = \dfrac{c}{P^z}$ the values of c and z can be evaluated from the data furnished by the curves, Fig. 23. We have

$$S = \frac{1107.5}{P^{0.581}} \text{ and also } S = \frac{K}{P^{1-z}}$$

Therefore $1-z = 0.581$ and $z = 0.419$

$$f = \frac{c}{P^z} = \frac{c}{P^{0.419}}$$

For $P = 1.5$ (60 m.p.h. stops being considered now)

we know that a fair average value for f is 0.10. Therefore

$$0.10 = \frac{c}{1.5^{0.419}}$$

for which

$$c = 0.12$$

Therefore an approximate relation between the mean coefficient of brake shoe friction and per cent braking power, resulting from the data of these tests (and applies therefore only to the range covered by these tests) for speeds of 60 m.p.h. plain cast iron brake shoes, clasp brake rigging, is

$$f = \frac{0.12}{P^{0.419}}.$$

WHEEL SLIDING

Tests were considered as having excessive wheel sliding when the sum of all slides was 3000 ft. or over in 12 car train tests and 250 ft. in single car tests. These arbitrary figures were chosen when an analysis of the wheel sliding data developed that the sum of all slides, when less than 3000 ft. was not sufficient to have any material effect on the length of stop and was usually made up of relatively short slides on a number of pairs of wheels, but when more than 3000 ft. several pairs of wheels usually slid for the greater part of the stopping distance, making the sum of all slides well above this figure. Slides under 15 ft. were not recorded.

With the No. 1 clasp brake, wheel sliding occurred at low as well as at high percentages of emergency braking power. These tests, however, were run between February 10 and March 5 when there was a comparatively low prevailing air temperature which, with the high humidity characteristic of the locality brought about an adverse rail condition. The bad rail condition was especially marked in the first tests of the day which, with few exceptions, were electro-pneumatic emergency applications at 150 per cent braking power.

Out of a total of 90 emergency tests at 150 per cent braking power made with the No. 1 clasp brake, 62 tests developed no wheel sliding at all. Of the 28 in which there was wheel sliding, 13 were the first runs of the day, previous to which there was a period of two hours when the track had not been run over by other trains. This permitted an accumulation of frost or moisture on the rail during that interval. Few tests, made subsequent to the first run of the day, showed excessive wheel sliding, and it may be concluded that the rail condition referred to was chiefly responsible for the sliding that occurred.

The tests with the other types of brake were made later in the spring when the weather was more favorable to good rail condition, and that in these tests there is a marked decrease in excessive wheel sliding.

An analysis of the percentage of runs with wheel sliding at various percentages of braking power shows that with plain shoes the amount of wheel sliding depends rather on the rail and weather conditions than on the percentage of braking power.

A total of 282 emergency tests at 150 per cent braking power were made with the various types of brakes; of this number 22 per cent had wheel sliding, 10 per cent occurring during the tests of the No. 1 clasp brake.

At 180 per cent braking power with plain shoes, wheel sliding occurred on but 7 out of 36 tests. With flange shoes sliding occurred in 11 out of 23 tests. In only one test of the 59, with 180 per cent braking power, was there wheel sliding amounting to over 3000 ft.

From the above it follows, that the determining factor in wheel sliding is not high braking power alone but rather the uncontrollable conditions of rail and weather in connection with it, against which no permanent provision can be made without a sacrifice in the length of emergency stops during those favorable periods of the day or seasons of the year when conditions warrant the use of high braking power.

Whether the sliding of wheels will or will not cause flat spots of a size sufficient to produce rough riding of the car depends entirely on circumstances; for example, a condition of rail surface which will cause a considerable amount of wheel sliding, with relatively low percentages of braking power, is a condition which at the same time will permit long slides to occur without producing noticeable flat spots. On the other hand, when the rail is in good condition, or in the extreme case of a sanded rail, a very short slide may produce flat spots of a size requiring prompt attention. No flat spots were obtained of sufficient size to necessitate changing wheels during the tests, although, on account of the number of small spots accumulated upon the wheel tread, it was found advisable to change some wheels before the cars were put back into regular service.

COEFFICIENT OF RAIL FRICTION

In determining the coefficient of rail friction by use of the rail-friction machine, the same section of rail was used at all times. The kinetic coefficient of friction, or the ratio of the force required to keep the weights moving slowly and the pressure of these weights upon the rail, was found to give more consistent readings than observations of the "static" coefficient.

The kinetic values determined range between 12 and 35 per cent, with the great majority of readings ranging between 22 and 30 per cent. The records, when taken in connection with simultaneous readings of air temperature and relative humidity, show that the coefficient of rail friction decreases with an increase in the relative humidity for temperatures below the freezing point, whereas the coefficient of rail friction is not greatly affected by high humidities as long as the temperature is high, but begins to fall as the temperature approaches the freezing point.

As an interesting study of the effects of these various factors, consecutive observations were taken of the coefficient of rail friction, air temperature, relative humidity and barometric pressure for a period of twenty-four hours. It is significant that the coefficient of rail friction obtained on the first reading in the early morning was practically the same as that found for a *well greased rail* later in the day.

There was no great consistency between the readings obtained for coefficient of rail friction and the amount of wheel sliding experienced. While as a rule the greatest amount of wheel sliding occurred during the first runs of the morning, at which time the coefficient of rail friction was usually low, it was also a fact that occasionally considerable wheel sliding would be experienced when the coefficient of rail friction observed previous to such tests had been about at its average value.

This led to the conclusion that other factors, such as shock, slack action, and foreign matter on the rail surface, have a controlling influence in causing wheel sliding.

Tests were made of the experimental device that was applied to the locomotive to give a higher maximum emergency braking power in a shorter time than is obtained with the standard ET equipment, in order to overcome the shock resulting from the maximum emergency braking power on the cars being higher and much more quickly obtained than that on the locomotive.

Comparative car and tender brake cylinder cards and slack action diagrams for 60 m.p.h. emergency stops, electro-pneumatic equipment, 150 per cent braking power on cars, with and without the higher braking power on the locomotive, shows that the sudden and considerable slack action on the records taken between cars 1 and 2, indicating the shock received at the draft gears about two seconds after the brakes are applied is much less severe when the locomotive is braked higher than normally. The result is a comparatively slow relative movement between cars, which is not noticeable to passengers.

V. GENERAL DISCUSSION OF STOPS

The shortest 60 m.p.h. emergency stop was made with a single car (locomotive not attached) with the No. 3 clasp brake electro-pneumatic equipment, 180 per cent braking power, and flanged brake shoes. The car was stopped under these conditions in 725 ft. The average retarding force for this test was 332 lb. per ton. This is equivalent to the resistance offered by a 16.6 per cent grade on which one end of a P-70 car (80 ft. long) would be 13.3 ft. higher than the other end.

This stop of 725 ft. from 60 m.p.h. made with a modern heavy passenger equipment car establishes a new record for a railway car stop.

Assuming a rail adhesion of 25 per cent, the shortest possible stop which could be obtained, by utilizing this adhesion to its maximum throughout the period of braking, would be 481 ft. This would require an ideal brake shoe and a controlling mechanism which would automatically adjust the retarding force of the brake, so that it would be at all times the maximum which could be used just short of producing wheel sliding.

The shortest 80 m.p.h. stop was made, with conditions the same as mentioned above, in 1422 ft. This is equivalent to an average retarding force of 310 lb. per ton.

From the data of stops made with locomotive alone and single car breakaway stops it is possible to calculate the approximate length of stop which would be obtained with a locomotive and train of twelve cars equipped with the electro-pneumatic brake.

Calculated from the results of single car breakaway tests, the best 60 m.p.h. train stop that could have been obtained with the means available during these tests is about 800 ft. and the best 80 m.p.h. stop about 1570 ft.

The shortest 60 m.p.h. train stop with a locomotive and train of twelve cars was 1021 ft. This was made with high braking power on the locomotive and No. 1 clasp brake, electro-pneumatic equipment, 180 per cent braking power and plain shoes on the cars.

The shortest 80 m.p.h. train stop was made in 2197 ft. with high braking power on the locomotive and with No. 1 clasp brake, electro-pneumatic equipment, 150 per cent braking power and plain shoes.

CHECK RUNS AND AVERAGES

In previous brake tests the average of two, or at the most three, stops under a particular set of conditions was thought sufficient to establish the average performance of the train, but a study of the situation revealed many variations in performance which could not be accounted for by any known differences in the equipment, adjustment, or manipulation. In order to determine the amount and cause of such variable performances as might result under supposedly constant conditions, a series of so called check runs was scheduled, one test to be made at the beginning and another at the end of each day's work, all conditions being kept the same throughout the entire series of tests as far as possible. These stops were all made from a speed of 60 m.p.h with the complete train, standard braking power on the locomotive, electro-pneumatic equipment, 150 per cent braking power, and plain shoes on the cars.

It was observed that after the brake shoes were well worn in and no change was made in apparatus or manipulation for a considerable period of time the check runs of such a group of tests would show but little variation (for example five such tests averaged 1181 ft., with a maximum only 8 ft. longer and a minimum only 11 ft. shorter than the average). However, when any change was made, such as in locomotives used, in per cent braking power of locomotive and tender, or

in brake shoes such as the replacement of a number of worn shoes by new ones, or the gradual wearing in of the brake shoes on the whole train, during the early part of a new series of tests, the length of stop obtained would vary, showing that the effect of new factors so introduced might be considerable.

The results of the complete series of check runs indicated that the variations are unavoidable, except by the most careful provision for the constancy of all factors which have an effect on the stop. The brake shoe bearing is the most difficult factor to control and at the same time it is the most potent in producing variations in brake performance.

An example of the importance of the brake shoe condition and the manner in which it can be affected was

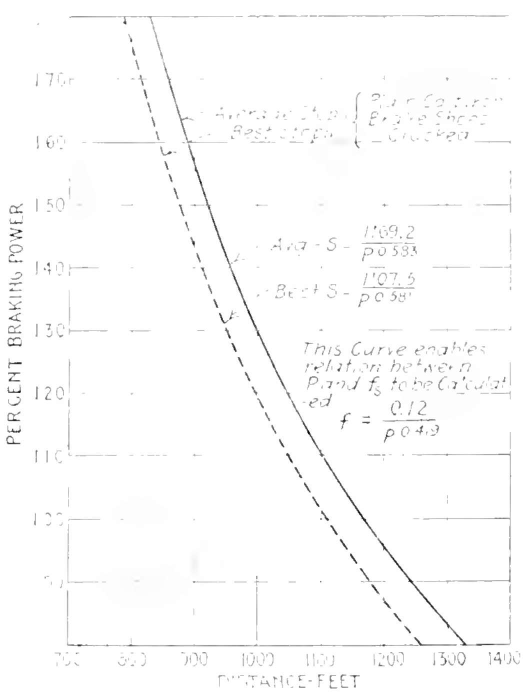


FIG. 23 CURVES SHOWING LENGTHS OF STOP IN SINGLE CAR EMERGENCY BREAKAWAY STOPS MADE WITH NO. 3 CLASP BRAKE, FROM 60 M.P.H. WITH THE ELECTRO-PNEUMATIC EQUIPMENT

afforded by one of the check runs with the standard (single shoe) brake rigging. This stop of 1049 ft. was the shortest 60 m.p.h. *train stop* actually made with 150 per cent braking power. Had the cars been stopped alone, i.e., without the locomotive, this stop would have been approximately 960 ft. This was not only the shortest stop made with this train, but was shorter than any check run with trains equipped with clasp brake rigging. It was made under peculiarly favorable conditions; while it was the first run of the day, the rail condition was good and the test followed nine tests at a low (90 per cent) braking power which insured the best possible shoe bearing. The favorable shoe bearing was further contributed to by the light service applications made during the movement of the train from and to the test ground and by the standing of the train over night.

On the other hand the *longest stops* of the check runs with any arrangement of brake rigging were also made with *this same train* (single shoe rigging), under identical conditions so far as could be provided, of air brake mechanism, brake rigging and all other controllable factors, but after the shoe conditions became unsatisfactory, due to many shoes running partially off the wheel. Three such stops were 1359 ft., 1361 ft., and 1389 ft. respectively from 60 m.p.h., or over 300 ft. longer than the short stops mentioned in the preceding paragraph. This shows that for a constant set of conditions (other than that of the brake shoes) the shortest and also the longest stops of the entire series of comparative tests were brought about by variations in brake shoe condition alone.

TESTS WITH NO. 3 CLASP BRAKE ON SINGLE CAR

The No. 3 clasp brake was applied to but one car and in making tests this car was separated from the locomotive before reaching the point on the test track at which the brakes were automatically applied, so that the stop of the car alone might be observed. This afforded an opportunity for controlling the conditions and insuring a freedom from influences other than those under investigation or beyond control which is attainable to a very much less degree in making breakaway stops with a number of cars and to a still less degree when making stops with a complete train of locomotive and cars. On the other hand, however, the fact that the individual cars necessarily differ in performance must not be overlooked, and the performance of a single car cannot be accepted unreservedly unless it is known that the car tested is fairly representative in every way of all cars in its class.

In studying the stops made with the No. 3 clasp brake, the distance of the stop being plotted against the actual per cent braking power realized, calculated from the brake cylinder pressure observed for each test, there was again shown a variation in length of stop of *nearly 300 ft.*, which can be attributed to variable brake shoe action alone, since other conditions were maintained substantially consistent. An important consideration in this connection is that this variation occurred when even the longest of the stops were themselves relatively short. This is a condition that renders any further shortening of the stopping distance by any of the means *within control of the designer*, an exceedingly difficult task.

GENERAL COMPARISONS OF STOP

Figs. 24-26 are chosen from the large number of similar comparisons contained in the complete report to illustrate how the data obtained permits of making a great variety of comparisons, according to the kind of comparative data desired. The diagrams are self ex-

planatory, showing average results expressed in terms of the length of the stop under different conditions of train make-up, air brake equipment on cars and locomotive, kind of brake application, per cent of braking power, type of brake rigging, type of brake shoes, and speed.

Certain variables were encountered during different tests which were found to have more or less effect on the comparative value of the averages. As there was no satisfactory means for compensating for these variables, however, such averages as are so affected have been classified as follows:

(1) Car stop affected by locomotive.

(2) Braking power decidedly lower than tests of other brake rigging or of the same brake rigging at other speeds, with the same air brake equipment.

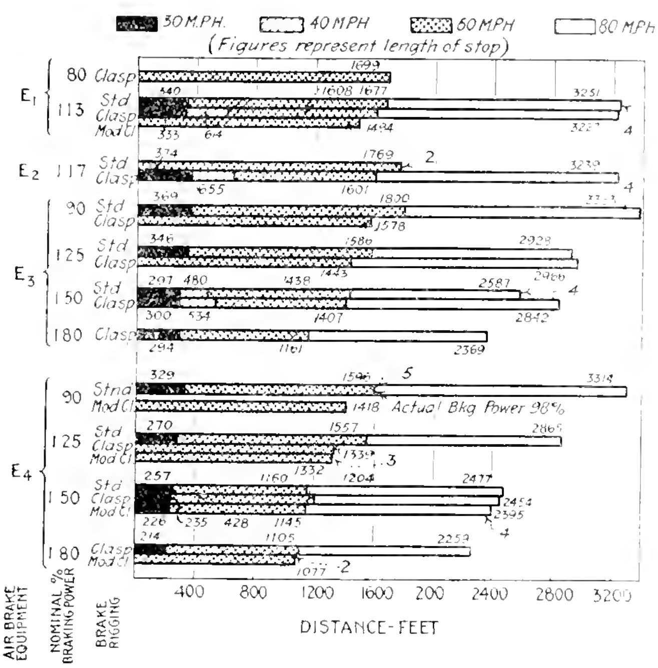


Fig. 24 Comparisons of Emergency Stops with Various Equipments and Nominal Percentages of Braking Power

(3) Braking power decidedly higher than on tests of other brake rigging or of the same brake rigging at other speeds, with the same air brake equipment.

(4) Speed 4 m.p.h. or more, less than nominal.

(5) Bad shoe condition.

COMPARISONS BETWEEN SINGLE CAR AND 12-CAR TRAINS

In making comparisons of the effects of the various percentages of braking power on the length of stop of the complete train of locomotive and 12 cars it should be remembered that the nominal per cent braking power (unless qualified) represents the braking power of the cars. In train tests, due to lower braking power of the locomotive and tender, the per cent braking power of the train, as a whole, is somewhat reduced.

For example with a K locomotive and tender half loaded the following table shows the braking power of the cars and of the train as a whole:

Twelve Cars	Twelve Cars and K Locomotive (Tender half loaded
90 per cent	90 per cent
113 " "	100 " "
125 " "	117 " "
150 " "	137 " "
180 " "	160 " "

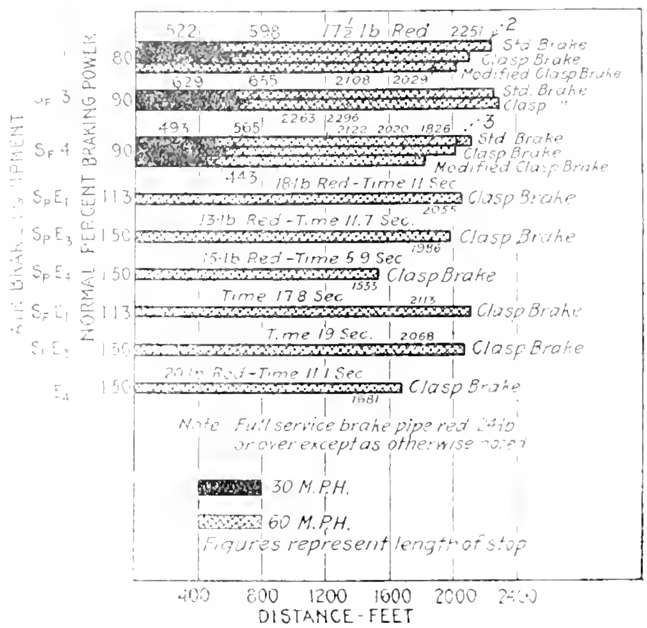


Fig. 25 Comparisons of Service Stops, and both Partial and Full Service Applications, Followed by Emergency, with Various Air Brake Equipments

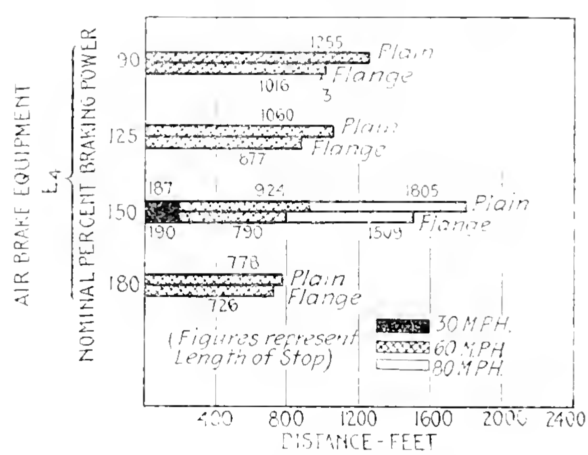


Fig. 26 Comparisons of Single Car Emergency Breakaway Stops with Various Nominal Percentages of Braking Power

The load on the tender was observed for each test, and due allowance was made for this in calculating the per cent braking power based on the actual brake cylinder pressure obtained for the entire train.

Figs. 27 and 28 illustrate the characteristic change

in length of stop for different initial speeds of the train, other conditions being substantially standard. Fig. 27 shows the average results obtained with locomotive and 12 car train using the ordinary standard (single shoe) brake rigging, electro-pneumatic air brake equipment and ordinary unflanged brake shoes with various percentages of braking power on the cars.

The curves shown for train stops from various speeds with the No. 3 clasp brake (Fig. 28) have been derived from the single car stops by assuming that the same ratio exists between the single car and train stops with the No. 3 clasp brake as was found to exist between the single car and train stops of the No. 3 clasp brake. This is believed to be the best possible calculation that can be made of the probable train stops with the No. 3 clasp brake (for which only single car breakaway tests were available) which would compare with those shown in Fig. 27.

From the data of all the single car, 60 m.p.h. breakaway stops, the curves of Fig. 29 have been plotted to show not only the observed relation between the length of stop and per cent braking power but also how this relation changed for different types of brake shoes and brake rigging tested and again, according to whether the several best or the average of all fairly comparative stops were considered.

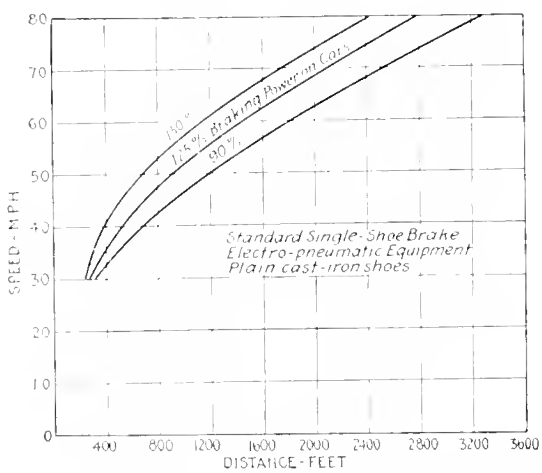


Fig. 27 Comparison of Full Train Emergency Stops, from Various Speeds and Percentages of Braking Power, Standard Single Shoe Brake

ESTIMATED TRAIN STOPS, NO. 3 CLASP BRAKE

The various types of car brake rigging used during the tests were applied to the 12 cars of the test trains, with the exception of the No. 3 clasp brake rigging. The No. 3 clasp brake was applied to but one car and all tests made in connection with this rigging were single car breakaway stops. In order to make the data of these tests comparable with the tests of other types of brake rigging it would be necessary to compute the probable 12 car train stops of the No. 3 clasp brake from the data of the actual single car breakaway stops. With this object in view a series of separate locomotive tests were made in order to determine accurately the performance of the locomotive.

When the electro-pneumatic equipment is used the probable stop of a train of any number of cars and locomotive may be calculated from the following approximate formula, when the length of stop and weight of a single car and of the locomotive are separately known. This method does not take into account the difference between the time elements of the brake action on the locomotive and on the cars, which, however, is very small with this equipment, its effect amounting to about three ft. in the computation of a 1000-ft. stop.

$$S_t = \frac{W_t S_1 S_c}{S_c W_1 + N S_1 W_c}$$

Where W_t = weight of train, locomotive and cars in lb.

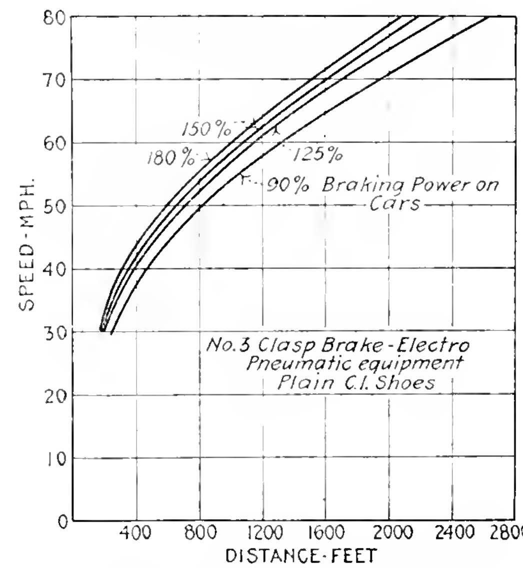


Fig. 28 Comparison of Full Train Emergency Stops from Various Speeds and Percentages of Braking Power, No. 3 Clasp Brake

W_1 = weight of locomotive in lb.
W_c = weight of a single car in lb.
S_t = length of stop of train in ft.
S_c = length of stop of a single car in ft.
S_1 = length of stop of locomotive in ft.

It will be noted that by means of the above formula a 12 car and locomotive train stop can be computed for any initial speed, provided the necessary single car and separate locomotive test data are known for the same speed.

For example, from the data of the best stops with the No. 3 clasp brake, flanged shoes, single car breakaway tests, we have:

W_c = weight of car = 125,200 lb.
$12W_c$ = 1,502,400 lb.
W_1 = weight of locomotive = 414,800 lb.
$W_t = W_1 + 12\,W_c$ = 1,917,200 lb.
S_1 = 1552 ft., stopping distance of locomotive alone from a speed of 60 m.p.h.

S_c = 991 ft., stopping distance of single car alone at 90 per cent braking power from a speed of 60 m.p.h.

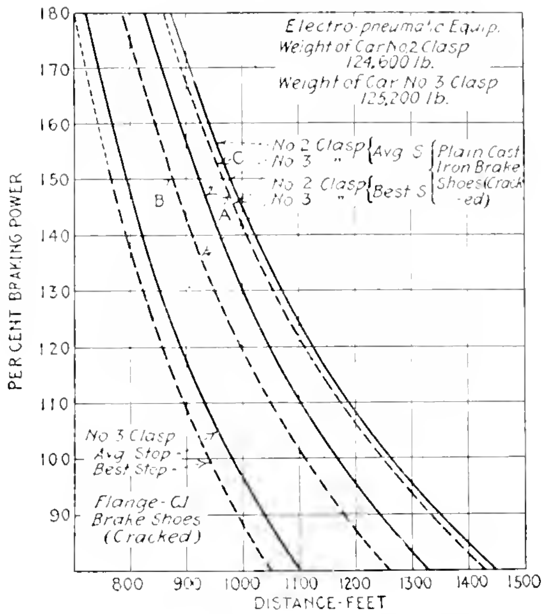


FIG. 29 COMPARISON OF SINGLE CAR BREAKAWAY STOPS FROM 60 M.P.H. AT VARIOUS PERCENTAGES OF BRAKING POWER

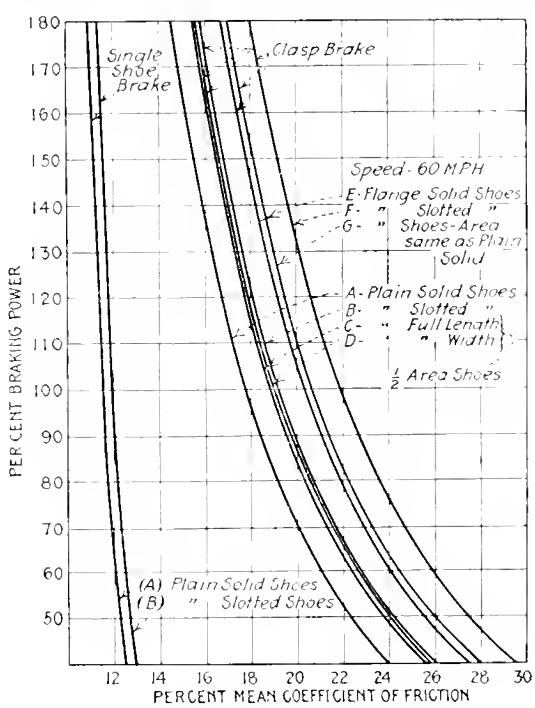


FIG. 31 CURVES SHOWING MEAN COEFFICIENT OF FRICTION ON TESTING MACHINE AT DIFFERENT BRAKING POWERS

Substituting these values in the following expression

$$S_t = \frac{W_t S_c S_1}{S_c W_1 + S_1\ 12 W_c}$$

we have
$$S_t = \frac{1{,}917{,}200 \times 991 \times 1552}{991 \times 414{,}800 + 1552 \times 1{,}502{,}400}$$

$$S_t = 1075 \text{ ft.}$$

Where the special high-pressure emergency bypass valve was used with the ET equipment on the locomotive, a shorter stop was obtained and in order to work out the train stop according to the above formula

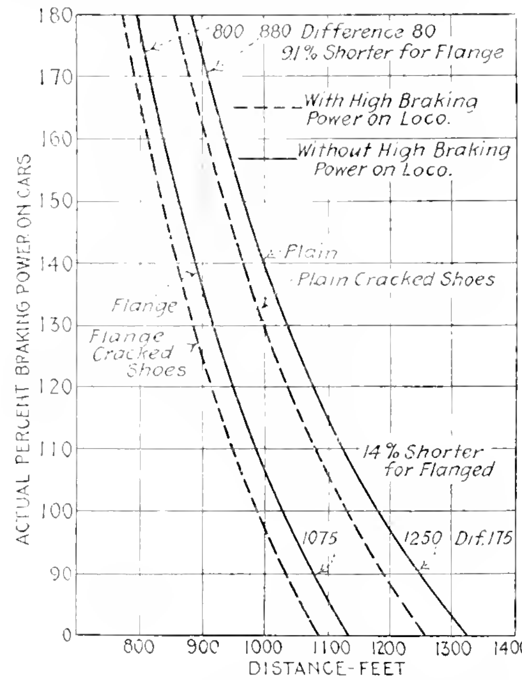


FIG. 30 COMPUTED TRAIN STOPS BASED ON BEST SINGLE CAR STOPS WITH NO. 3 CLASP BRAKE

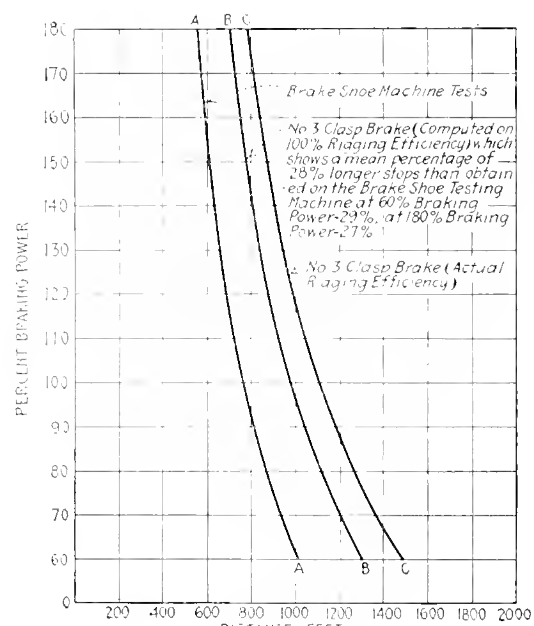


FIG. 32 CURVES SHOWING RELATION OF MACHINE TO ROAD TESTS

for this condition it would be necessary to substitute for the value of S_1 = 1552 ft., the value of S_1 = 1228 ft., which was the average stopping distance of the locomotive from a speed of 60 m.p.h. when using the special high-pressure emergency bypass valve.

The data of the best single car breakaway stops made with the No. 3 clasp brake from a speed of 60 m.p.h. at

various percentages of braking power, with both plain cracked and flanged cracked shoes, are shown in Fig. 29. Using these data as a basis and combining with them the data of the separate locomotive tests, complete train stops were computed as described and have been plotted in Fig. 30. It will be noted that for each type of shoe two curves are shown. In each case the dotted and solid lines represent the train stops which would be obtained if the locomotive were operated respectively with or without the special high-pressure emergency bypass valve.

Fig. 30 is also of interest in that it shows the gain from the use of flanged instead of unflanged shoes. The best single car breakaway stop with flanged shoes from 60 m.p.h. and 180 per cent braking power was 725 ft. This is equivalent to a 12 car train stop, using the standard ET locomotive equipment, of 795 ft. (Fig. 30).

BRAKING POWER, SERIAL ACTION AND SHOCKS—LOW SPEED STOPS

There is but little on record concerning the likelihood of shocks due to a high emergency braking power quickly applied at low speeds, although the general impression is that emergency applications, even at 60 miles per hour or over, are likely to be rough or even dangerous to passengers. This is a wrong impression. It is well known to all who have observed the action of brakes at high speeds (and it was the invariable experience during these tests) that the higher the speed the less noticeable is the application of the brakes.

The use of the UC pneumatic and electro-pneumatic equipments at the same speeds, percentages of braking power and otherwise similar circumstances, afforded an opportunity to demonstrate the most important fact in this connection, namely, that the amount of braking power, by itself, has but little to do with the shock experienced. The rate of transmission of serial brake application in relation to the rate of build up of brake cylinder pressure on each car or, in other words the action of the slack between the different vehicles in the train, is the controlling factor. With the electro-pneumatic brake, in which simultaneous quick action of the brakes on all vehicles is obtained, there was no shock at any speed or percentages of braking power except the slight shock on the first few cars due to the running out of slack which was to be expected on account of the relatively low braking power on the locomotive. On the other hand with the pneumatic equipment, having an appreciable time interval between the application of the successive cars in the train, shocks were experienced.

The most marked evidence of the effect of the time element in the serial action of the brakes and resultant shocks, occurred during the emergency stops made from very low speeds. In four tests made with the UC pneumatic equipment at ten and at twenty miles per hour, the resulting shocks, especially in the last third of the train, were extremely severe, being in effect a collision between the forward end of the train, which was almost stopped, and the rear end upon which the brake application was having but little, if any, effect at the time the rear end run-in occurred. The fact that this test was made with the UC pneumatic equipment, which was relatively slow in transmitting serial quick action, undoubtedly caused more severe shocks than will be experienced with the considerably smaller time element of the universal valve as subsequently modified.

That shocks disappear entirely when the time element in the application of the successive brakes in the train is eliminated was shown by repeating the 10 m.p.h. stop using the electro-pneumatic equipment. Notwithstanding that the stop was made in a shorter distance than before (37 ft., instead of 42 ft., and 45 ft. respectively), the difference in the action of the train was marked. There was no shock or violent slack action, although a very high rate of retardation was produced.

CHARACTERISTIC SPEED, RESISTANCE, DECELERATION AND POWER CURVES

During any stop the retardation at different instants is dependent upon the resultant normal pressure of the brake shoes on the wheels, the instantaneous value of the coefficient of brake shoe friction, and the effect of the air and internal resistances. The difference between the effects of the rotative energy of the wheels and the opposing air and internal resistances is relatively so small, compared with that due to the action of the brakes, that it does not require consideration here. The brake resistances increase as the brake cylinder pressure increases, during the time the brakes are being applied. After the maximum brake cylinder pressure is reached with the UC equipment, no further change in brake cylinder pressure takes place. Consequently, the resultant normal pressure is substantially constant from that point to the end of the stop. If the coefficient of brake shoe friction was constant throughout the stop, the resultant resistance and retardation would then be constant, and the speed-distance curve would be a true parabola, while the speed-time curve would be a straight line. It will be of interest to check these conclusions with the results obtained in several typical tests.

In order to study the relations of the factors above mentioned to the best advantage, typical single car breakaway stops, and stops with the locomotive alone have been chosen, which eliminates the disturbing influences of slack action (which produce apparent changes in retardation which are not characteristic of the train as a whole), the variations in the retardation on the different vehicles comprising the train (which would require the averaging of all data for all cars in

order to arrive at a satisfactory relation between cause and effect), the non-uniformity of brake rigging and brake shoe conditions (which can not be as satisfactorily controlled on a train of a number of cars as on a single car) and the variable effect of the locomotive. Speed-time and speed-distance curves were plotted from the track chronograph records of the various stops chosen, and from the speed-time curve, time-deceleration and resistance curves have been plotted, the ordinate at any point on the deceleration curve being proportional to the slope of the tangent to the speed-time curve at the corresponding point.

The curves showing deceleration and resistance are not horizontal lines beyond the point where the brake becomes fully applied. The resistance is not constant but changes more or less as the speed of the train is reduced, especially toward the end of the stop, where a considerable and continual increase in retardation is experienced. As pointed out above, this occurs during the time the brake cylinder pressure is constant, and consequently the resultant normal brake shoe pressure is substantially constant. The conclusion, therefore, follows that the other factor, viz., the coefficient of brake shoe friction is changing and that the character of the changes which it undergoes is accurately portrayed by the deceleration curves derived as explained. This characteristic change in the coefficient of brake shoe friction has been a matter of common observation in every instance where train tests or laboratory tests of brake shoes have been studied from this point of view. A further analysis of the influences which bring about the characteristic variations in brake shoe friction will be found in the chapter on Brake Shoes.

Having the deceleration and resistance curve thus plotted on a time basis, the value of the resistance at different distances from the point of brake application can be determined by the aid of the speed-time and speed-distance curves. In this way, the distance-deceleration and resistance curves were plotted. The work done during any portion of the stop is proportional to the area under the distance-resistance curve.

In order to obtain the average resistance to the motion of the train, it is necessary to integrate this curve. The shape of the curve at the beginning is determined by the more or less rapid rate of rise of brake cylinder pressure, which depends upon the kind of brake equipment being used. In order to arrive at a relation between the force developed in the brake cylinder or at the brake shoe, and the resulting retarding force, it is advantageous to consider this relation from the standpoint of constant brake cylinder, or shoe pressure, throughout the stop. Consequently, it is desirable to replace the effect of the variable pressures acting during the time the brake is being applied by their equivalent effects, had the maximum pressure developed and held throughout the stop, been realized instantaneously. This can be done by determining the point of equivalent instantaneous application of retarding force, which is the point at which the maximum retarding force initially developed could have been applied instantaneously to produce the same effect on the speed of the train, as was realized from the gradual building up of retarding force that actually occurred. The amount of work required to reduce the initial speed of the train to the value which existed at the time the retarding force reached its initial maximum value, is proportional to the area under the distance-resistance curve up to this point. The same amount of work would be represented if the gradually rising resistance curve were replaced by a vertical line, representing the development of the same maximum retarding force instantly, but at a point such that the work done in the two cases is the same.

Having determined the point of equivalent instantaneous application of the retarding force, the average resistance, *during the time that the brake may be considered fully applied*, can be found by integrating the area under the entire distance-resistance curve and dividing this area by the total length of stop minus the distance from the start to the point of equivalent instantaneous application.

TABLE 2 EMERGENCY 12 CAR TRAIN STOPS FROM 60 M.P.H

Brake Rigging	Brake Shoes	Air Brake Equipment	Nominal Braking Power	Stop Best	Stop Avg.
Standard	Plain	PM	113	1659	1677
Standard	Flanged	PM	113	1453	1453
No. 1 clasp	Plain	UC pneumatic	125	1405	1443
No. 2 clasp.	Plain	UC pneumatic.	125	No tests	
No. 1 clasp.	Plain	UC electro-pneumatic	125	1338	1339
No. 1 clasp.	Plain	UC electro-pneumatic	150	1157	1204
No. 2 clasp..	Plain	UC electro-pneumatic	125	1317	1332
No. 2 clasp.	Plain	UC electro-pneumatic	150	1097	1145
No. 3 clasp.	Plain	UC electro-pneumatic (estimated)	125	1055	
No. 3 clasp.	Plain	UC electro-pneumatic (estimated)	150	965	
No. 3 clasp.	Flanged.	UC electro-pneumatic (estimated)	125	935	
No. 3 clasp.	Flanged	UC electro-pneumatic (estimated)	150	860	

A SUMMARY OF GENERAL RESULTS WITH A TWELVE CAR TRAIN

Table 2, giving emergency 12 car train stops from 60 miles per hour summarizes the stops obtained during the road tests and shows briefly the gain in stopping distance to be obtained by the use of flanged shoes, clasp brakes and the UC pneumatic or electro-pneumatic equipment.

VI. BRAKE SHOES

Prior to starting the tests it was arranged to have the brake shoes made from special heats and to be as near as possible to the normal composition of standard cast iron shoes in order that the variation in brake

shoes might not affect comparisons of air brake equipment and the brake rigging. Before applying these shoes to the test train they were broken in on other trains to wear off the face surface or slight chill incident to foundry practice. When so broken in, with an average of 1/8 in. of thickness removed from the face, Brinell hardness readings of the surface were taken and the shoes grouped according to hardness numbers.

At the time of breaking-in the shoes for the test train a series of tests was made to determine the variation in hardness with respect to wear. The results of this investigation showed that when the shoe is new a wide variation in hardness may be expected between shoes made from the same heat, but that as the shoe wears down the hardness becomes fairly uniform and remains so, decreasing slightly as the shoe wears out. Although at that time no data were available, it was thought that Brinell hardness was an indication, not only of the ultimate strength of the face metal of the shoe but also was related in some way to the coefficient of friction. Later tests confirm this belief, but at this time the degree of this relation is not known. The indications are, however, that the harder the cast-iron material the lower will be the coefficient of friction and that the highest possible coefficient of friction from cast iron (at least under clasp brake conditions) is obtained with a material approaching the condition of the shoe when about three-fourths worn out and having a Brinell hardness number of about 190.

The greatest uniformity of action and the highest friction seem to be obtained when the brake shoe bearing on the wheel is best. This condition would naturally be expected to follow a series of relatively light applications in the course of which the effects of temperature in warping the shoe are kept a minimum.

It may be seen here that this most desirable condition is precisely what results from the continued use of the brakes during service stops on the road and consequently the brake shoes as worn in ordinary train service are in the most favorable condition for making short emergency stops. In the tests this condition appeared at times to have been reached after several light braking power runs. Stops following such a series of runs were then shorter than similar stops following several tests at higher braking powers, other conditions being the same. This result seemed to be most consistently obtained with the single shoe train.

The schedule of tests with the No. 3 clasp brake was arranged with this in mind, but the effect was not so noticeable in this case, there being indications that a good shoe bearing with the clasp brake might follow a small number of tests made at high braking power as well as a much larger number of tests made at lower braking power. The influence of previous tests on the shoe bearing for any particular test under consideration is so obscured by other conditions, such as the general wearing in of the shoes that necessarily results at any braking power, that the observations of the effect of the shoe dressing runs are of questionable value.

A consideration of the results of the warping of the shoe led to the conclusion that the warping could be largely eliminated by slotting or cracking the shoes so that they would be more free to conform to the contour of the wheel. As a matter of fact, this cracking takes place with either plain or flanged shoes after a number of runs have been made.

As a further study of the influence of bearing area on the performance of brake shoes, tests were made with the same shoes as in the slotted shoe tests but with the ends broken off and their area reduced by 50 per cent. The first stop was made in 1031 ft. This was almost as short as the shortest stop made under similar conditions with the full area unslotted shoes (1007 ft.). Subsequent tests with these partial area shoes resulted in stops of 1210, 1190, 1193 and 1134 ft. All of these stops were with the brake shoes at a high temperature. These results tend to confirm the conclusion that the bearing area rather than the total face area of the shoe is the important factor in brake shoe performance, and that the bearing area on the first test with half area shoes was substantially as effective as that of the full area solid shoes which were undoubtedly affected by warping to a considerably greater extent. Furthermore, the much longer distances run in the four stops following the first with the one-half area shoes demonstrated the effect of shoe temperature which was offsetting the probable tendency of the better bearing area condition originally secured as a result of the reduced warping effect.

The advantage of an increased bearing area was demonstrated beyond question by the fact that the use of flanged brake shoes after being worn to a satisfactory bearing, resulted invariably in a shorter stop than under similar conditions with unflanged shoes. The shortest stops made in the entire series of tests were with flanged brake shoes and their use shortened the stop approximately 12 per cent as compared with the best similar tests in which unflanged shoes were used under similar conditions. This comparison is illustrated graphically in Fig. 30.

Up to the time of these tests there was no definite laboratory test information which would apply to the particular braking conditions under investigation, especially with reference to the actual brake shoe performance as distinguished from the brake rigging performance. To supplement the road tests, a series of laboratory tests was carried out on the brake shoe testing machine of the American Brake Shoe and Foundry Company, at Mahwah, N. J.

A study of all the bearing area measurements leads to the conclusion that none of the values of the bearing areas determined are sufficiently accurate to establish a true relation between bearing area, pressure density and mean coefficient of friction. However, the data

are such that it is possible to conclude that *the magnitude of the bearing area does change throughout the stop* and is greatest near the end of the stop. It was noticed that the bearing area shifted; that is to say, a spot which was found in the bearing area early in the stop, was found in the non-bearing area later in the stop.

To determine the effect of bearing area upon the mean coefficient of friction, the mean value of the brake shoe bearing area throughout the stop is necessary, rather than the total and relatively high value observed after the stop. A study of the data in a general way shows that the greater the pressure per square inch of bearing area, the lower will be the mean coefficient of friction.

The temperature observations taken cannot be used to establish a definite relation between the temperature of the working metal and the mean coefficient of friction, for the actual temperatures existing *at the bearing area* were not determined. The readings evidently indicated only the temperature of that portion of the shoe surrounding the pyrometer element. If this portion of the shoe happened to be in working contact with the wheel, the temperatures would be correspondingly high, but when the bearing area shifted to some other place on the face of the shoe the pyrometer indicated merely the temperature increase due to the conduction from that part of the shoe at which the heat was being generated.

For this reason the maximum temperature readings were very erratic and it was found that the only method which would give uniform temperature readings was to allow sufficient time after an observed maximum reading to permit the heat to become uniformly distributed by conduction throughout the whole shoe. It was found that the shoe temperature thirty seconds after maximum was consistent and proportional to or a function of the initial test speed, because the total amount of energy dissipated by the shoe in any stop will be proportional to the square of the speed and while some of this energy will pass into the wheel in the form of heat and some will pass off with the sparks, a proportional amount will produce a rise in the temperature of the shoe as a whole.

However, it is not reasonable to look for evidences of the effect of the temperature of the whole brake shoe on the coefficient of friction, when it is appreciated that *the temperatures at the working surfaces greatly exceed the maximum temperatures ever reached by the shoe as a whole.* Consequently for a correct understanding of the relation between temperature and coefficient of friction it is necessary to examine minutely the phenomena which occur during the development of brake shoe friction and to study the action of the materials immediately concerned in this process.

Fig. 33, to an enlarged scale, illustrates how the slight inequalities of the two surfaces in contact can interlock and resist relative movement. If the top surface is regarded as stationary any movement of the lower surface in the direction indicated by the arrow will be resisted by a force made up of two components:

a Tearing or abrasion of some of the surface projections which are interlocked; in other words, by shearing off the interlocking projections.

b By the lifting or unlocking of some of the surface projections which would require forcing the surfaces apart against the normal pressure until the minute projections on the surface successively cleared.

In brake shoe friction the first component, namely, tearing or abrasive action between the minute interlocked portions of the bearing surfaces is the important factor. Consequently the retarding force developed bears some relation to the ultimate strength of the metal which undergoes abrasion, because the action of abrasion consists of the pulling apart, or crushing of the particles of the contact surfaces. Practically none of the abrasive action takes place on the wheel, due to the harder and tougher nature of the wheel surface and the fact that the surface of the wheel is not continuously in contact with the brake shoe while the brake shoe *is* in continuous contact with the wheel. Inasmuch as the tearing or abrasion of the metal particles can take place only in the thin layer of the shoe metal which is in contact with the wheel, and as the actual contact area is but a portion of the total face area of the shoe, it is evident that the generation of the retarding forces and consequent absorption of the energy of the moving train is dependent upon but a *very small quantity of brake shoe metal.*

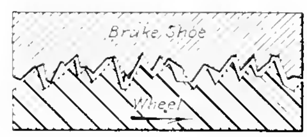


Fig. 33 Diagram of Friction between Brake Shoe and Wheel

The result of this condition is that the metal in the state of abrasion undergoes a very rapid rise in temperature; and the indications are that the temperature of the working areas of the brake shoe is changing continuously, because when one set of particles is torn off energy is dissipated in the form of heat so that the next particles to be torn off are at a higher temperature than the first. This process appears to continue until the surface of the metal in abrasion reaches such a temperature that the force required to tear the particles away is greatly reduced. The abrasive action then seems to be extremely rapid until the bearing of the shoe shifts to some other and cooler spot on its surface, not previously in the same degree of contact with the wheel. The action may then be repeated and the bearing area may thus shift from one portion of the surface to another during the stop.

Unquestionably the constantly changing temperature of the contact surface has an important relation to the force of retardation developed by the tearing down of the metal particles. The resistance due to abrasion is dependent on the ultimate strength of the cast iron. It is well established that above a critical temperature (approaching 900 deg. fahr.) the ultimate strength of cast iron decreases rapidly and that at or above red heat temperatures (1400 deg. to 1800 deg. fahr.) its ultimate strength is greatly reduced.

The force of retardation due to abrasion and the corresponding mean coefficient of friction will therefore be a function of the constantly changing, but always high, temperature of the working metal. Obviously the lower the mean temperature can be maintained, the higher will be the mean coefficient of friction as long as this average temperature is above the critical temperature at which the ultimate strength of cast iron is a maximum.

Unless the brake shoe is of such a nature or in such a condition that a large proportion of its face area is in working contact with the wheel, and remains so, the principal factor in producing high friction for any given braking condition appears to be the frequent shifting of the bearing area from the heated to the cooler spots over the face of the shoe. If a shoe has a relatively small bearing area, that cannot shift, the wheel is forced to wear the highly heated and ineffective shoe metal rapidly away, and successively exposes cooler metal, which is better able to offer resistance and absorb energy.

If the friction characteristics developed by a given brake shoe under a given combination of conditions depend, as appears probable from the foregoing considerations, upon the frequent shifting of the contact areas of the shoe surface, the instantaneous as well as the average values of the frictional resistance of the brake shoes during a stop are functions of: (*A*) The fit of the shoe to the wheel; (*B*) the flexibility of the shoe; (*C*) the available bearing area.

A The fit of the shoe to the wheel has an important influence on the facility with which the contact area can shift. If an ordinary metal brake shoe fits well, according to the ordinary understanding of this expression, it necessarily cannot bear on the wheel equally at all portions of its surface. But when wear takes place, only a comparatively small amount of metal has to be worn off the bearing spots in order to bring cooler spots into contact, and consequently a good fit of the shoe will guarantee against the possibility of the bearing area being held concentrated at any particular spots, after they have become heated to a point where the metal breaks down rapidly and offers a comparatively poor resistance.

B The effect of warping is clearly shown by the comparative performance of a solid shoe of any type and a similar shoe slotted so as to make it more flexible. In every case the slotted shoe has a decided advantage. With a warped shoe the bearing area cannot shift readily and consequently the average temperature of the working metal is high and a correspondingly low mean coefficient of friction is obtained. During the tests of the solid shoes, a shoe would often be observed to be warped in such a manner that it touched the wheel only at each end while at the center of the shoe the two surfaces were 1/32 in. apart, although the full braking power was applied to the shoe to force it against the wheel. Under such conditions the temperature of the bearing area would rise until the red heat had penetrated the shoe fully 1/8 in. In such cases the bearing area would not shift to a cooler part of the shoe until sufficient metal had been worn off to offset the effect of the warping. The uneven heating effect caused by the concentration of the bearing area at the two ends of the shoe would in turn cause the shoe to warp so that the ends of the shoe would be drawn away from the wheel and the bearing area again held for a comparatively long time at one spot at the center of the shoe. Such tests invariably resulted in longer stops or lower mean coefficient of friction than was the case with the same type of shoe slotted.

The resulting higher average temperature of the working metal due to the action of warping also resulted in a greater rate of wear. All the data of shoe wear show that shoes of the same type and hardness had a high rate of wear per unit of energy absorbed when a low coefficient of friction was developed and likewise a lower rate of wear when a higher coefficient of friction was developed. In other words when the coefficient of friction is high, the average temperature of the working metal must be comparatively low and therefore the metal torn from the surface of the shoe works more effectively because it is at a lower temperature and consequently less metal is required to do a given amount of work.

C The shifting of the bearing area will tend to be more rapid if the size provides more available area for shoe bearing. The average working temperature will also be reduced because a shoe of large area, such as a flange shoe provides better facilities for radiating and conducting heat away from the working surfaces. This is borne out by the better performance of the flange shoes in comparison with the plain shoes, both solid and slotted.

The results of both road and machine tests on brake shoes have shown that the coefficient of friction under any condition of braking power is dependent upon the initial speed, and the coefficient of friction tends to decrease as the speed is increased. This condition can be expected from the fact that the total energy to be absorbed during a given stop is always proportional to the square of the initial speed. The effect of the higher speeds is to increase the rate at which the temperature of the working metal changes, and although

the actual bearing areas will shift more rapidly, the greater tendency to a general heating of the shoe reduces its ability to conduct or radiate heat from the face of the shoe. For these reasons the average temperature of the working metal is consistently higher at higher speeds, and the coefficient of friction correspondingly lower.

VII. CONCLUSIONS

AIR BRAKE

The characteristics of the mechanism available for controlling the air pressure in the brake cylinders determine in a large measure the length of the emergency stop, the reliability and flexibility of the brake operation in service applications and in general the safety, convenience, comfort and economy of train control.

The state of the art has been advanced to a marked degree in all of these directions by the developments of recent years as exemplified in the apparatus used in these tests. What has been accomplished can be broadly summarized as follows:

(*A*) Desired results are insured with greater certainty.

(*B*) Undesired results are guarded against more effectively.

(*C*) An adequate capacity for present and future requirements is provided.

In service applications with the improved (UC) equipment a greater flexibility of operation is provided. That is, the braking power per pound of brake pipe reduction is lower, thus giving the engineer a greater time in which to use judgment when manipulating the brakes. At the same time, however, the maximum braking power obtainable in a full service application is higher.

A more sensitive and prompt release of the brakes is insured, tending to improve the releasing action of all brakes in the same train of mixed old and new equipments.

The action of the old and the new equipments mixed in the same train is harmonious and free from rough slack action or shocks both in service and emergency operation.

The UC equipment is adaptable to any weight of car and may be installed to furnish any desired nominal per cent of braking power.

With the new equipment operating electrically or pneumatically, there is always available a quick acting and fully effective emergency brake. This is not the case with the old equipment, in which the relation of the service and emergency functions is such that a quick action application could not be obtained after a service application of any consequence. The following average results indicate the degree to which this difference has an effect on the length of stop. Considering the ordinary full service stop from 60 miles per hour with both brakes (say 2000 or 2200 ft.) as 100 per cent, the attempt to make an emergency application with the old equipment does not produce any shorter stop than if only a full service application were made. With the improved apparatus operating pneumatically, an emergency application following a partial service application will shorten the stop about 14 per cent and after a full service application about 10 per cent.

With the electro-pneumatic brake these figures are respectively 23 and 15 per cent.

An electrically controlled brake application has been recognized as ideal ever since the report to this effect presented by the Master Car Builders' Committee in charge of the famous Burlington Freight Brake Trials in 1886 and 1887, for the reason that thereby the time element in starting the application of the brakes on various cars in the train is eliminated, a correspondingly shorter stop made, and the possibility of shocks at any speeds removed. With the new brake apparatus the effectiveness of the pneumatic emergency application is so considerably increased that the saving in time due to electric control has proportionately less influence on the length of stop, but its effect in eliminating serial action and consequently the possibility of shocks due to brake application is of correspondingly greater importance.

The graduated release feature of the improved brake apparatus permits stops to be made shorter, smoother and with a greater economy in time and compressed air consumption.

The new apparatus can be applied to give only the equivalent of the old standard apparatus if desired but in such a form the complete new apparatus can then be built up by the addition of unit portions to the simplest form of the mechanism.

The electro-pneumatic brake acts as an automatic telltale in cases of malicious or accidental closing of an angle cock after the train is charged by permitting all the brakes to apply, it being thereafter impossible to release the brakes behind the closed cock until the cock is opened.

The PM equipment will start to apply on a brake pipe reduction of 2 lb. A 4-lb. brake pipe reduction is required to start an application with the UC equipment, thereby preventing undue sensitiveness to application on slight, unavoidable fluctuations in brake pipe pressure. As a bona fide service reduction of more than 4 lb. continues, the rate of attainment of braking power is the same as if no stability feature had existed.

The attainment of full service braking power on the entire train with the UC equipment operating pneumatically was 16 seconds, 33 per cent longer than with the PM equipment because of the smaller size reservoirs used for greater flexibility.

Full service braking power was obtained in nine seconds with the electro-pneumatic brake but without sacrificing desirable flexibility because of the increased

sensitiveness of control when operating the brakes electrically.

The time of transmission of serial quick action through the brake pipe is practically the same with UC and PM equipments.

The time to obtain full emergency braking power with the PM equipment on the entire train was 8 seconds; with the UC equipment operating pneumatically 3.5 seconds or 56 per cent shorter; with the electro-pneumatic equipment 2.25 seconds or 72 per cent shorter.

The gain in emergency stopping power of the electro-pneumatic equipment over the PM equipment results from: (*a*) the shorter time occupied in applying the brakes; (*b*) a higher brake cylinder pressure obtained; (*c*) the holding of the pressure as obtained, without blow-down, as with the high-speed reducing valve of the PM equipment.

Designating the time of equivalent instantaneous application of retarding force by t, and the braking power, corresponding to the brake cylinder pressure obtained, by P, the values of t for emergency applications with the PM equipment 12 car train range from 2 to 2.5 seconds, for the UC pneumatic from 2 to 2.5 and for the electro-pneumatic from 0.7 to .85 seconds.

The observed average value for P, with the PM equipment (for a nominal 113 per cent braking power on the cars) ranges from 95 per cent to 100 per cent. With the UC pneumatic equipment and electro-pneumatic equipment, nominal emergency braking powers of 90, 125, 150 and 180 per cent were used, which, due to locomotive effect, become for the complete train 90, 117, 137 and 160 per cent respectively.

With the electro-pneumatic brake a uniform increase in per cent of braking power results in a substantially uniform decrease in length of train stop. An increase of 5 per cent in braking power reduces the length of stop about 2 per cent within the range of braking powers tested.

The available rail adhesion varies through wide limits, e.g., from 15 per cent in the case of a frosty rail early in the morning to 30 per cent for a clean, dry rail at mid-day.

The amount of wheel sliding depends more on the rail and weather conditions than on the per cent braking power. Some sliding was experienced with braking powers as low as 90 and 113 per cent where rail conditions were unfavorable, but 180 per cent braking power did not cause wheel sliding with good rail conditions.

The effect of excessive wheel sliding was to make the length of the stop about 12 per cent greater than similar stops without wheel sliding.

A braking power low enough to eliminate the possibility of wheel sliding on a bad rail results in longer stops than could be considered satisfactory for general service. Since good rail conditions prevail a large part of the time, the preferable emergency braking power is that which, considering the installation conditions, will stop trains at all times in as short a distance as can be accomplished without trouble from wheel sliding in such cases as are to be anticipated when emergency stops have to be made under unfavorable rail conditions. Advantage might be taken of this fact to use a higher braking power in summer than could be used in the winter with the same degree of freedom from objectionable wheel sliding.

The relation between the opposing forces on the wheel when sliding is about to commence can be expressed as follows:—

$$F = H_m$$
$$Pwef_s = wf_r$$
$$P = \frac{f_r}{ef_s}$$

in which

F = tangential retarding force of shoe on wheel
H_m = maximum force of friction between wheel and rail (at instant of slipping)
P = nominal per cent braking power
w = weight on wheel, lb.
e = transmission efficiency of brake rigging
f_s = coefficient of brake shoe friction
f_r = coefficient of rail friction

This establishes the value of the per cent braking power which must exist at each instant of the stop if the vehicle is to be brought to rest in the *shortest possible* distance.

But it has already been shown that if other conditions are constant a change in braking power will produce a corresponding change in the mean coefficient of brake shoe friction, the relation derived for the conditions under consideration being

$$f_s = \frac{0.12}{P^{0.419}}$$

Substituting this value of f_s in the above equation for P, we have

$$P = \frac{f_r P^{0.419}}{0.12e}$$
$$P^{0.581} = \frac{f_r}{0.12e} = \frac{8.33f_r}{e}$$

For a 60 m.p.h. stop on a good rail f_r can safely be taken at 25 per cent and e for four-wheel trucks can be made at least 85 per cent.

Then

$$P^{0.581} = \frac{8.33 \times 0.25}{0.85}$$

for which

$$P = 470 \text{ per cent}$$

This, of course, is beyond the range of the tests which furnished the data from which the relation $f_s = \frac{0.12}{P^{0.419}}$ was derived, and consequently the result signifies nothing more than that, under the conditions assumed above, an extremely high nominal braking power would be

necessary in order to cause the wheels to slide. As a matter of fact, tests at about 400 per cent nominal braking power are on record in which practically no sliding occurred.

On the other hand, considering the variation in coefficient of brake shoe friction and rail friction that must be counted upon in service, it is advisable to limit the tangential retarding force, F, to a value less than H_m by an amount I which is proportional to the degree of protection against wheel sliding considered necessary under the ordinary condition of rail likely to be encountered, including also due allowance for the effect of surges in the train, non-uniformity of braking conditions on different vehicles, reasonable protection against excessive wheel sliding under bad rail conditions and all other causes tending to cause the wheels to slide.

The equation of condition is then

$$F = H_m - I$$

The value of I is entirely arbitrary, due to the wide range of variation of its elementary factors, according to locality, time of year, state of weather, character of train and equipment and so on.

For the purpose of illustrating the extreme opposite to that given above, suppose that I be taken as $0.25\ H_m$. Then

$$F = 0.75 H_m$$

$$P = \frac{0.75 f_r}{e f_s}$$

Again assuming the relation $f_s = \frac{0.12}{P^{0.419}}$ as above, we have

$$P^{0.581} = \frac{6.25 f_r}{e}$$

Considering $e = 85$ per cent as before and taking $f_r = 12$ per cent, which was the lowest observed rail friction, under as poor rail conditions as could well be imagined, we have

$$P^{0.581} = \frac{6.25 \times 0.12}{0.85}$$

from which $P = 81$ per cent.

As a matter of fact some wheel sliding was obtained during the tests with 85 per cent to 90 per cent braking power when very bad rail conditions prevailed. For practical purposes a conservative value for f_r would be 15 per cent. If now a nominal braking power of 150 per cent is used the corresponding margin I against wheel sliding can be calculated from the formula $I = kH_m$ and $F = H_m - kH_m = (1 - k)\ H_m = CH_m$; from which $C = \frac{F}{H_m} = \frac{Pef_s}{f_r} = \frac{P^{0.581}e}{8.33 f_r}$

Substituting the values $P = 1.5$, $e = 0.85$ and $f_r = 0.15$, we have

$$C = \frac{(1.5)^{0.581} \times 0.85}{8.33 \times 0.15}$$

from which $C = 0.86$

therefore $F = 0.86 H_m$

and $k = 1 - C = 0.14$

That is to say, *under the assumed conditions*, when using a braking power of 150 per cent with as bad a rail condition as is represented by the extremely low value $f_r = 15$ per cent, the mean retarding force developed by the brake shoe is still 14 per cent less than the adhesion of the wheel to the rail.

The amount of wheel flattening when sliding occurs depends upon the weight upon the wheels, the materials in the wheels and rails, and the condition of the rail surface. The rail surface may be such that relatively long slides will produce but small flat spots, or, conversely, short slides may produce flat spots of a size requiring prompt attention.

When the UC equipment is used on the cars an arrangement giving a high emergency braking power on the locomotive, with a blow-down feature, has advantages as follows:

(*a*) Shocks between locomotive and cars practically eliminated

(*b*) Shorter stops

(*c*) No more wheel sliding than to be expected with the present installation of ET equipment.

BRAKE RIGGING

An efficient design of brake rigging must be produced before the advantages of improved air brakes or brake shoes can be fully utilized.

The use of the clasp type of brake rigging eliminates unbalanced braking forces on the wheels and so avoids the undesirable troublesome journal and truck reactions that come from the use of heavy braking pressures on but one side of the wheel. This has an important effect not only on freedom from journal troubles but also in enabling the wheel to follow freely vertical inequalities of the track.

The clasp brake also improves the brake shoe condition materially, both as to wear and variability of performance.

Although the clasp brake rigging will produce better stops than a single shoe brake rigging equally well designed (other conditions being equal), its advantage in this direction is of less importance than in the improved truck, journal and shoe conditions mentioned above.

The tests indicated that at least 85 per cent transmission efficiency could be obtained with either single shoe or clasp brake rigging.

The following features were observed to be of importance if maximum overall brake rigging efficiency is to be secured:

(*a*) Protection against accidents that may result from parts of rigging dropping on the track.

(*b*) Maximum efficiency of brake rigging at all times to insure the desired stopping with a minimum per cent of braking power.

(c) Uniform distribution of brake force, in relation to weight braked, on all wheels.

(d) With a given nominal per cent braking power, the actual braking power to remain constant throughout the life of the brake shoes and wheels.

(e) Piston travel to be as near constant as practicable under all conditions of cylinder pressure.

(f) Minimum expense of maintenance and running repairs of brake rigging between the shopping of cars.

BRAKE SHOES

The brake shoe bearing was the most difficult factor to control and at the same time the most potent in producing variations in brake performance.

The tests established the possibility of a variation of 15 to 20 per cent in length of stops from 60 m.p.h. with all factors except brake shoe condition remaining substantially constant. Continued stopping with moderate braking pressures produced a constantly improving brake shoe condition and shorter stops. This is evidence that with reasonable attention to brake shoe maintenance, the condition of the shoes on cars in ordinary road service is likely to be more favorable to making short emergency stops than during a series of tests in which the brake shoes are worked severely.

The difference in the efficiency of the clasp and single shoe rigging may offset the gain which might be expected from difference in coefficient of friction and vice versa. Consequently as neither of these factors could be observed uninfluenced by the other, a satisfactory comparison of the mean coefficient of friction under different rigging conditions or of different types of rigging or air brake apparatus under variable shoe conditions in road tests, is impossible.

High braking powers from high initial speeds result in a great heating of the working surface of the shoe and a rapid abrasion. This effect is most marked under severe braking conditions such as obtained when heavy cars equipped with one brake shoe per wheel are stopped.

Shoes of the same type and hardness had a high rate of wear per unit of energy absorbed when a low coefficient of friction was developed and, conversely, a lower rate of wear when a higher coefficient of friction was developed.

Both the road and the laboratory tests confirmed previous tests and conclusions from analysis that the temperature of the working metal is the determining influence in coefficient of brake shoe friction. The other factors that may be involved become effective chiefly as they affect the change of temperature of the working metal.

The general performance of the shoes as observed during the road tests formed the basis of the program established for laboratory tests, which resulted in the following deductions:

(a) The generation of the retarding forces and consequent absorption of the energy of the moving train is dependent upon but a very small quantity of brake shoe metal.

(b) The actual bearing area rather than the total face area of the shoe is the important factor in brake shoe performance.

(c) The magnitude of the bearing area changes throughout the stop and is greatest near the end of the stop.

(d) The bearing area shifts continuously from one portion of the surface to another during the stop.

(e) The principal factor in producing high friction for any given braking condition is the frequent shifting of the bearing area from the heated to the cooler spots over the face of the shoe.

(f) Slotted shoes or shoes that are cracked are more flexible than solid shoes and the bearing area shifts more readily than in the case of solid shoes.

(g) With shoes of the same type and approximately the same hardness, the wear per unit of work done is less with the slotted shoe than with the solid shoe. The stops with slotted shoes were always shorter and the mean coefficient of friction higher than with solid shoes.

(h) The shifting of the bearing area will tend to be more rapid if the size provides more available area for shoe bearing.

(i) The greater the pressure per square inch of bearing area, the lower will be the mean coefficient of friction.

(j) Flanged shoes provide more available area for bearing than unflanged shoes.

(k) The use of two shoes instead of one per wheel will result in a higher coefficient of friction and less wear per unit of work done.

(l) A comparison of the values of mean coefficient of friction for standard and for clasp brake conditions indicates a decided advantage for the clasp brake throughout the entire range of braking powers. The gain in favor of the clasp brake with slotted shoes amounts to about 40 per cent, at a braking power of 180 per cent, and 100 per cent, at a braking power of 40 per cent, an average gain for the whole range of braking powers of about 70 per cent.

(m) From a brake shoe standpoint the advantage of using two shoes instead of one shoe per wheel may be summed up as follows:—

First. The clasp brake shoe is associated with but one-half the wheel load and consequently has but one-half as much energy to absorb.

Second. The clasp brake shoe is working at only one-half the shoe pressure at which the standard shoe must work under the same braking power.

Third. The *available* working area for the same amount of energy to be absorbed is double.

A possible source of disadvantage when using two shoes per wheel is that a warped or poorly bearing shoe is subjected to less pressure tending to force it into a good contact with the wheel. For this reason, though the available shoe area is doubled when using clasp brakes, the actual *amount of working metal* throughout the stop may be less than with a single shoe, which is less capable of resisting the tendency of the heavier pressure to cause a better fit of shoe to wheel.

This, and an especially good shoe condition due to previous moderate pressure tests in each case, is an explanation why three of the 60 m.p.h. 150 per cent braking-power electro-pneumatic stops with the single shoe train were shorter by 50 ft. than the best stops of either of the first or second clasp brake trains.

On the other hand the disadvantage and greater variability of the single shoe brake is evidenced in the fact that under the same conditions as cited above two stops with this train were longer than the longest stops without material wheel sliding made with either of the two clasp brake trains.

With plain solid shoes the durability will be increased 41.1 per cent under clasp brake conditions as compared with that under single shoe conditions.

With plain slotted shoes the durability will be increased 33.5 per cent under clasp brake conditions as compared with that under single shoe conditions.

The superior durability of the plain slotted shoe as compared with the plain solid amounts to 11.7 per cent under single shoe brake conditions and 5.9 per cent under clasp brake conditions.

The wear of the flanged solid shoes per unit of work done is 19 per cent less than for plain solid shoes, and for flanged slotted 26 per cent less than for plain slotted shoes, or 30 per cent less than the plain solid shoes.

The wear of plain slotted shoes per unit of work done is 5.4 per cent less than the wear of plain solid shoes, and the wear of the flanged slotted is 13.2 per cent less than the wear of flanged solid shoes.

For the same amount of work done flanged solid cost 16 per cent less than plain solid shoes, and flanged slotted cost 23 per cent less than plain slotted, or 27 per cent less than plain solid shoes.

Approximately 135 per cent more stops will be required to wear out the flanged solid than will be required to wear out the plain solid shoe; 158 per cent more stops to wear out the flanged slotted than the plain slotted shoe, and 171 per cent more stops to wear out the flanged slotted than the plain solid shoe.

For any given braking condition with cast-iron brake shoes the indications are that the best relation will exist between shoe wear and the mean coefficient of friction when the Brinell hardness of the cast iron is about 190.

Machine and road tests show a difference in stopping distance for the same type of shoe under the same braking conditions.

The effect of the difference in wheel surface conditions is one of the leading factors which go to make up the difference between machine and road tests. The difference in braking performance can be established and the factor expressing this difference be applied to laboratory results to predict the performance of a car or train.

LENGTH OF STOP

The stops and observed performance of the air brake, brake rigging and brake shoe are in agreement with the relation generally assumed to exist between the speed and other variables mentioned and resultant length of stop. This relation for straight, level track and neglecting air and internal friction on the one hand and the rotative energy of the wheels and axles on the other hand, is:

$$S_t = 1.467Vt + \frac{V^2}{30P_t f}$$

in which the terms have the following significance and range of values according to conditions

S_t = length of stop to be expected in ft.

V = initial speed of train in m.p.h.

t = time at the beginning of the stop during which the brakes are to be considered as having no effect, to allow for the time element in the application of the brakes

	Kind of Air Brake Equipment PM	UC Electro-Pneumatic
For a 12-car train		
t ranges from.	2.0	0.70
t ranges to..	2.5	0.85

P = nominal per cent braking power corresponding to the average cylinder pressure existing for that portion of the stop after the brake is considered fully applied.

With a single car or several similar cars, stopping without the locomotive attached, the value of P can be obtained from an average of all brake cylinder indicator cards or taken from one typical brake cylinder card, provided all cylinder pressures and foundation brake installations are substantially alike.

Where car weights differ or where the locomotive is attached, the average per cent braking power (P) for the train (total weight W) may be calculated from the formula

$$P_t = \frac{\Sigma P_c W_c + P_n W_n + P_e W_e}{W_t}$$

in which

P_c = nominal per cent braking power corresponding to average cylinder pressure of cars as noted above

W_c = weight of car in lb.

W_n = actual total weight of tender in lb.

P_n = nominal per cent braking power corresponding to tender cylinder pressure and to W

W, weight of engine in lb.

P, nominal per cent braking power corresponding to engine cylinder pressure (aggregate for driver, truck and trailer wheels according to distribution of weights and nominal braking power)

$e \times f$ = product of efficiency of brake rigging and mean coefficient of brake shoe friction, in which

e varies with the type and installation of brake rigging and with the per cent braking power, though the latter effect can be but slight throughout the range of ordinary emergency braking powers

f varies with the kind and initial condition of the brake shoe bearing surface, the initial speed and the various influences affecting the conditions of the bearing surface during the stop.

As no satisfactory separate determination of e and f was found possible the combined factor $e \times f$ is given in the following table, the values being representative of the best performance that might reasonably be expected under conditions comparable with those of this test.

TABLE 3 VALUES OF $e \times f$.

Kind of Brake Rigging		Clasp Brake		Single Shoe[1]	
Type of Brake Shoe					
Speed m.p.h.	Braking Power	Plain	Flanged	Plain	Flanged
30	125	0.111	0.169	0.108	0.112
	150	0.129	0.154	0.099	0.103
	180	0.118	0.141	0.090	0.094
60	125	0.103	0.122	0.074	0.090
	150	0.094	0.112	0.068	0.082
	180	0.086	0.102	0.062	0.075
80..........	125	0.092	0.109	0.070	0.071
	150	0.084	0.100	0.064	0.068
	180	0.077	0.092	0.059	0.062

[1] Value of data uncertain due to non-uniform brake shoe conditions.

DISCUSSION

J. P. Kelley[1]: To the author's statement that the sliding of wheels under brake applications is due largely to rail adhesion, I am inclined to add that the percentage of braking power employed is not of itself the cause of sliding. With the trucks and gears that are familiar to us, the braking forces are not evenly distributed over all the wheels and it is possible for the weight to be momentarily shifted from one or more of the wheels during the progress of a stop with brakes applied.

From a study of clasp brake design and foundation brake gear, as well as from experience, I should say that the clasp brake is the only suitable one to use on present day passenger car equipment. While it will not do away with the shock, it will go a long way towards keeping the wheels in their normal position with relation to the other parts of the truck, and to the rails, and so aid in making available whatever spring action is there to keep the wheels where they belong and to keep the rail adhesion uniform and constant. By this means the pressure on the wheels is balanced; also the number of hot boxes, is reduced.

We have had considerable experience with clasp brakes on quite a number of our cars during this present winter, and with a few of them the previous winter, and find that as the shoe is higher above the rail in an emergency application than with the common type of gear, there is less chance for the accumulation of snow and ice on the shoe to drip off upon the rails when the shoe gets hot, and so reduces the friction.

To show that uneven braking power rather than the per cent of braking power considered in itself is productive of wheel sliding, a recent case may be cited of a train of nine cars, where the highest braking power would probably run 115 per cent, the lowest about 65 per cent, and the average through the train about 85 per cent. Through an accident the brake pipe was broken off on the fourth car from the rear. Every car ahead of the rear car came to a stop without injury to the wheels. They were the ones on which the braking power was very low. The rear car had normal braking power, and all but two pairs of its wheels were slid flat. This could be explained on no other principle than that when the brake application was initiated at the fourth car, and propagated in opposite directions, there was not only the braking power acting on the wheels, but also the effect of shock set up because of the difference in time and the difference in the power with which the brakes went on, which "jumped" the wheels along and caused them to skid to such extent as to break or very materially reduce their rail adhesion.

With reference to emergency application, if a brake will operate instantaneously and simultaneously throughout the train, with almost any degree of flexibility, emergency stops, as such, can be very materially reduced. A brake that will operate instantaneously will bring a train to a stop with a service application, within a distance for which another brake equally powerful but much slower in action, would require an emergency application.

H. H. Vaughan. A point which is brought out in these tests, is the trouble with wheels sliding. About a year ago we went into the question of flanged shoes to reduce the brake shoe pressures, and found an extraordinary increase in wheels slid, especially in cold weather. We then tried unflanged shoes, without any other change, and the sliding reduced. I have no reason to give for this, but it is a point worth bringing up, and the sliding of wheels, while shown in rather a curious way in this paper, is really a very serious and expensive thing, especially in cold weather, in which I am pleased to say I have had a large and most unlimited experience. Wheels sliding with us is undoubtedly a prominent cause of shelled out tires. When it is known that we rarely run a car over 6000 miles in winter without having a wheel with shelled out tires, it can be imagined how serious it is.

Regarding the paper in general, one is impressed by the marvelous ingenuity of the whole apparatus. It is a wonderful piece of mechanical invention, and one cannot help wondering where we are going to get to in this air brake matter. Probably there was never a more ingenious machine than the plain triple valve invented by Mr. West-

[1] Cons. Air Brake Engr. of the N. Y. C. & H. R. R. R. Co.

inghouse, which made possible the use of automatic air brakes on passenger equipment. In 1887, when the Burlington tests were being conducted, Mr. Westinghouse supplemented his plain triple valve by the quick-action triple, which again was a peculiarly brilliant invention and the fame of Mr. Westinghouse as an inventor will probably rest more on these two inventions, which are the foundation of our modern air brake system, than on all the other things he has done.

The quick-action triple valve behaved very well during the early years of its life, but about the time when it was twenty years of age, like many of us, it began to branch out, and there was attached to the quick service application the retarded release and then a reservoir or two was annexed to the air brake system, giving the graduated release and higher pressure in emergency. There was the LN, and then the PC, and now we are to have the UC, the greatest development of all, which will work either pneumatically or electrically. If the electrical part breaks down, the pneumatic part comes on and works, and the whole thing is wonderful, all the way down from the plain triple, as a monument of inventive genius.

At the same time—I do not wish to raise a discordant voice—are we wise, are the railroad companies wise, is the Westinghouse Company wise, in this development in which the apparatus is continually being revised to interchange with all the other developments that have gone before it? Would it not be possible to design the electro-pneumatic brake without this complication? It is a wonderful thing, but should it be put on every passenger car without very serious consideration?

I consider that the Westinghouse Company, supplementing this paper, should tell us what is necessary in the straight electro-pneumatic brake in which the train pipe carries the air and the electricity does the application, and I venture to say, without knowing exactly what would be the answer, that it would be an exceedingly simple and highly efficient apparatus. I cannot help thinking that an electro-pneumatic brake, even with the safety automatic feature on the air pipe, so that a fracture of an air pipe would cause the application of the brakes, would not be anything like the complicated apparatus we are getting today in order to make these things interchangeable and universal.

W. B. TURNER[1] said in response to Mr. Vaughan's remarks on the complexity of air-brake apparatus that the electro-pneumatic brake has been used for traction service for the past seven years under several thousands of cars; and has been used on the subway system in New York for several years, which is the most severe service in the world, where it has given good results. The electro-pneumatic apparatus can be applied to practically any equipment that has been built up to the present time and will function in a satisfactory manner, but it will not do what the improved air brake equipment (type UC) described in the paper will accomplish. To attain the results which have been detailed it is essential to have this equipment or its equivalent. While he would welcome any apparatus that was less complex, this would be impossible if it is desired to do the things which are necessary to control the trains of to-day in the best manner possible. If Mr. Vaughan had his double brake equipment and the supplemental devices for cutting-out the brakes etc., he would find that the equipment would be vastly more complex than that shown in the paper—it would be so complex that he would be afraid of it himself.

Mr. Turner then presented the following written discussion:

The present day conditions in railroading that affect the air brake problem are:

a Higher Speed, because the energy to be dissipated increases as the square of the speed, which means, other things being equal, that the length of the stop will also increase as the square of the speed.

b Heavier Vehicles, because doubling the weight doubles the energy to be dissipated. The combined effect of doubling the speed and doubling the weight is to increase the energy to be dissipated eight times.

c Longer and Heavier Trains. These increase the difficulty of control and greatly magnify reactions due to "slack" between cars.

d Greater Frequency of Trains. This increases the probability of accident and therefor the necessity for more efficient control.

e Parallel Tracks. This also increases the danger, as an accident on one track may cause one on any of the other tracks.

Any one of these changes in conditions makes imperative a compensating change in effectiveness in the means for controlling trains, but when they are all taken collectively, as they must be, the seriousness of the problem is even more apparent and, to one who knows the potential, alarming. But this is not all, for the very conditions that thus called for more effective brake appliances also decreased the efficiency or effectiveness of those existing by almost one-half. The predicament, therefore, is one requiring prompt attention and the creation of means not heretofore in existence.

The reasons why the above-mentioned conditions decrease the effectiveness of the brake control are:

Increased speed (work) causes a decrease in the mean coefficient of friction; and as the stopping distance is proportional to the coefficient of friction, the stop becomes longer.

Heavier vehicles also increase the work required of the brake shoe in a given time, and this further reduces the coefficient of friction. Also, as a result of the greater forces exerted, there are distortions and consequent losses in foundation brake gear efficiency. Again, much larger brake cylinders are necessary and this increases the time required to get full braking power, these three losses contributing, as is apparent, to a further material increase in stopping distance.

Longer trains lead to another decrease in effectiveness by adding to the time required to get the brakes on, while the combination of greater weight and length increases the volume of air required with consequent difficulty of recharging quickly. There is also the difficulty of controlling trains smoothly because of the bunching and stretching of such a number of heavier cars and the time lapse between the brakes applying on the front and rear end of the train.

Greater frequency of trains and parallel tracks make improvement necessary by requiring much more frequent brake applications, thus exhausting the air supply, and also by making it imperative to be able to obtain maximum emergency

[1] Chief Engineer of the Westinghouse Air Brake Company.

braking force at any time. Collectively, it will be seen that these changes mean much, nor must it be overlooked that one serious effect is the increased risk we must take with the human element.

To illustrate the foregoing by example, in 1890 with a train weight of 280 tons and a speed of 60 miles per hour, the energy to be dissipated was about 33,000 ft-tons and the stopping distance was 1000 ft.

In 1913, with a train-weight of 920 tons and a speed of 60 miles per hour, the energy to be dissipated is 111,000 ft-tons, or almost four times greater than that of the first mentioned train. With an old-style brake the collision energy as this train passed the point where the first mentioned train stopped would still be 48,000 ft-tons, or one and one-half times what the first mentioned train had before the brake was applied and there would still be 760 ft. to run.

This modern train, but now equipped with the new brake apparatus, running at a speed of 60 miles per hour, can be stopped in 860 ft., at which point, with the old brake equipment, it would still be running at 43 miles per hour and with a collision energy of 57,000 ft-tons or still about twice that contained in the train of 1890 at the beginning of the stop.

When the full force and meaning of the increased stopping distance is realized, in connection with the possibility of accidents arising from the greater frequency of trains and number of parallel tracks, it will be seen that not only are improvements in brake equipment really necessary, but also that the best that can be designed is none too good.

F. W. Sargent. In conducting machine tests of brake shoes it is our practice to make a number of runs to get the shoes down to a good bearing and then make a number of records and average them. The average figures derived from repeated tests upon different shoes should be comparable with the results that might be obtained from the brake-shoe equipment of a train. The great variation in the train records as presented in the paper must be due, I think, to some neglect in the foundation brake rigging, rather than to a bad condition of all the brake shoes at one time.

The agreement between the results of the brake shoe testing machine and the road tests is extremely gratifying. When we first began testing brake shoes on the machine we encountered very large variations in the results, particularly with the heavy solid new shoes. But as the shoes wore down, and especially when they cracked and fitted the wheels better, the results became more uniform. When the shoes became thin and near the point where they ought to be removed, it developed that under the extreme pressures common to modern high-grade equipment, with the single brake, we were reaching the danger point and there was a possibility of the shoe melting. Such a condition would be realized on the road if the brakes were applied on a grade and then an emergency stop followed while the shoes were still warm. Under such a condition the shoes might be heated to a point where they would lose their grip on the wheels to a large extent, even if not melted away, and cause the brake to fail. It seems to me that the only thing which will prevent this is the adoption of the clasp brake. Besides saving the brake shoe from possible destruction, the test records indicate that with the two shoe combination there is an actual gain in the retardation.

R. R. Potter.[1] It may be of interest to speak of some tests made recently on the New York, Westchester & Boston Railway, to determine the efficiency of the clasp brake. The cars, which are operated electrically, weigh 60 tons, and are run as high as 60 miles an hour. In making the test, a motor truck without motors, which has clasp brakes, was put under the trailer end of the car, which normally has a simple truck. At 35 miles per hour the deceleration under an emergency application of the brake was found to be 4 miles per hour per second with the clasp brake; with the simple brake, it was 3.3 miles per hour per second. At 50 miles per hour, the deceleration was 3.65 miles per hour per second with the clasp brake, and with the standard brake, 3 miles per hour per second. The length of stop with the clasp brake, at 50 miles per hour, was 585 ft., and with the simple or standard brake 690 ft. These were the average lengths of stop for about 40 stops. Invariably the stops were shorter when the clasp brake was used. Stops were made at various speeds, principally at 35 and 50 miles per hour.

S. G. Thomson.[2] I am particularly interested in the business end of this new brake, the part which involves its practical application. After listening to the discussion, the important thing to me seems to be the development of the foundation brake. Have we tried out the foundation brake far enough? Have we gone far enough with the clasp brake in increasing the friction applied on the wheels and are we not going too far for the present in this development of the electric control? I am inclined to agree with Mr. Vaughan in respect to the matter of complications.

We have had considerable experience with the clasp brake on our road for a number of years, running it on 100 or more cars, with four and six-wheel trucks, high-speed service. All are giving excellent results, so that it seems to me more important at the present time to extend the use of the clasp brake than to hasten the electric development. Let the electric control be a matter of gradual unfolding.

How much benefit would this electric control as presented here to-night be to us? I figure that the principal gain would be in the little time saved by applying a considerably greater pressure in the brake cylinder; also that there would be a considerable advantage in making an emergency application after the service application has been made. Is that really of sufficiently great importance in actual train service to warrant all this complication and expense?

T. L. Burton. Both Mr. Sargent and Mr. Vaughan have spoken of the wheel sliding effect of the flanged brake shoe. I have had considerable experience with this and, as the former stated, have found the trouble with the flanged shoe to be due largely to the brake gear, especially the spacing of the heads on the brake beams and the deflection of the beams under various loads.

There has been a question in the minds of some as to the relative stopping effect of the clasp and single-shoe types of brake, all conditions, excepting the performance of the gear and the shoe, being the same. For any set of conditions such as stated in Table 10, the length of the stop should be inversely proportional to the value of $e \times f_s$; consequently, so far as the brake shoe and rigging are concerned, Table 3

[1] Supt. of Equipment, N. Y. W. & B. Ry.
[2] Supt. M. P. and Rolling Equip., Phila. & Reading R. R.
Westinghouse Air Brake Co., 165 Broadway, New York

affords a precise means of comparing the length of stops obtained with the various types of brake gear and brake shoes used in the test with which the report deals.

I have prepared some supplementary tables, reducing Mr. Dudley's comparison to a percentage basis. Accepting the values of t and f_s as shown in Table 3 for clasp brakes and flanged shoes as 100 per cent, the relative length of stops for clasp and single shoe brakes should be as follows:

RELATIVE LENGTH OF STOP

Speed in M. P. H.	Per Cent Braking Power	Clasp Brakes: Plain Shoes	Clasp Brakes: Flanged Shoes	Single Shoe Brake: Plain Shoes	Single Shoe Brake: Flanged Shoes
30	125	$\frac{0.169}{0.141}=1.199$	$\frac{0.169}{0.169}=1.000$	$\frac{0.169}{0.108}=1.565$	$\frac{0.169}{0.112}=1.509$
30	150	$\frac{0.154}{0.129}=1.194$	$\frac{0.154}{0.154}=1.000$	$\frac{0.154}{0.099}=1.556$	$\frac{0.154}{0.103}=1.495$
30	180	$\frac{0.141}{0.118}=1.195$	$\frac{0.141}{0.141}=1.000$	$\frac{0.141}{0.090}=1.567$	$\frac{0.141}{0.094}=1.500$
60	125	$\frac{0.122}{0.103}=1.184$	$\frac{0.122}{0.122}=1.000$	$\frac{0.122}{0.074}=1.648$	$\frac{0.122}{0.090}=1.356$
60	150	$\frac{0.112}{0.094}=1.191$	$\frac{0.112}{0.112}=1.000$	$\frac{0.112}{0.068}=1.647$	$\frac{0.112}{0.082}=1.366$
60	180	$\frac{0.102}{0.086}=1.186$	$\frac{0.102}{0.102}=1.000$	$\frac{0.102}{0.062}=1.645$	$\frac{0.102}{0.075}=1.360$
80	125	$\frac{0.109}{0.092}=1.185$	$\frac{0.109}{0.109}=1.000$	$\frac{0.109}{0.070}=1.557$	$\frac{0.109}{0.074}=1.473$
80	150	$\frac{0.100}{0.084}=1.190$	$\frac{0.100}{0.100}=1.000$	$\frac{0.100}{0.064}=1.563$	$\frac{0.100}{0.068}=1.471$
80	180	$\frac{0.092}{0.077}=1.195$	$\frac{0.092}{0.092}=1.000$	$\frac{0.092}{0.059}=1.559$	$\frac{0.092}{0.062}=1.484$

INCREASE IN LENGTH OF STOP WITH THE SINGLE SHOE BRAKE AS COMPARED TO THE CLASP BRAKE

Speed in M. P. H.	Per Cent Braking Power	Plain Shoes Per Cent	Flanged Shoes Per Cent
30	125	$\frac{1.565}{1.199}-1=0.305=30.5$	$\frac{1.509}{1.000}-1=0.509=50.9$
30	150	$\frac{1.556}{1.194}-1=0.304=30.4$	$\frac{1.495}{1.000}-1=0.495=49.5$
30	180	$\frac{1.567}{1.195}-1=0.311=31.1$	$\frac{1.500}{1.000}-1=0.500=50.0$
		$\frac{1.648}{1.184}-1=0.392=39.2$	$\frac{1.356}{1.000}-1=0.356=35.6$
		$\frac{1.647}{1.191}-1=0.383=38.3$	$\frac{1.366}{1.000}-1=0.366=36.6$
		$\frac{1.645}{1.186}-1=0.387=38.7$	$\frac{1.360}{1.000}-1=0.360=36.0$
		$\frac{1.557}{1.185}-1=0.314=31.4$	$\frac{1.473}{1.000}-1=0.473=47.3$
		$\frac{1.563}{1.190}-1=0.314=31.4$	$\frac{1.171}{1.000}-1=0.471=47.1$
		$\frac{1.559}{1.195}-1=0.304=30.4$	$\frac{1.184}{1.000}-1=0.484=48.4$
Average Gain in favor of Clasp Brake, Per Cent..		35.5	44.6

Tabulated results show the following *average* comparative lengths of stops:

Average stop, clasp brake, plain shoes . .	1.191
Average stop, clasp brake, flanged shoes.	1.000
Average stop, single-shoe and plain shoes. . .	1.590
Average stop, single-shoe and flanged shoes.	1.446

Length of stop with clasp brake, plain shoes is 19.1 per cent greater than stop with clasp brake, flanged shoes.

Length of stop with single shoe brake, plain shoes is 59.0 per cent greater than stop with clasp brake, flanged shoes.

Length of stop with single shoe brake, flanged shoes is 44.6 per cent greater than stop with clasp brake, flanged shoes.

Also, length of stop with single shoe brake, plain shoes is 33.5 per cent greater than stop with clasp brake, plain shoes.

Whence the *general* average length of stop with the single shoe brake is $\frac{1}{2}$ (44.6+33.5)=39.05% greater than the general average length of stop with the clasp brake.

The relative stopping distance of the two types of brake gear, however, tells but half the story. Mr. Dudley refers to the sliding of wheels as affected by the adhesion between the wheels and the rail. The adhesion is influenced, not only by the condition of the rail, but by the shifting of the wheel loads as affected by inertia forces, and shocks and lines of action in the brake gear.

Unfortunately, we have no control over the condition of the rail, or the effect of the inertia. The use of electro-pneumatic brakes will, however, minimize the shifting of wheel weights resulting from end shocks, and a careful analysis of many brake gears in use will disclose some remarkable facts on the equalization of wheel weights and shoe pressures as influenced by the design and application of the gear.

With the assistance of Mr. H. M. P. Murphy of our organization, we have made an analysis of the brake forces of some trucks in use on a road in this territory and their effects on the equalization of weights at wheels and shoe pressures.

I will add in brief form some results of the analysis for the brake rigging of a six-wheel passenger car truck. The tabulation relates to braking forces, wheel pressures on rail, percentage of braking power, etc., for service application, with all parts standard; and for emergency application, with shoes and tires worn and journals displaced in accordance with actual conditions observed. The nominal braking power in service was 85 per cent and in emergency, 160 per cent. The total actual weight of car under the standard conditions assumed for service is 142,000 lb. Under the worn conditions assumed for emergency the total car weight is 138,000 lb.

NORMAL BRAKE SHOE PRESSURES: SERVICE

	Leading Truck	Rear Truck.
Outside wheel	9155 lb.	8825 lb.
Middle wheel	9775 lb.	9175 lb.
Inside wheel.	8130 lb.	8215 lb.

Variation in normal brake shoe pressure = 1645 lb.; per cent variation = 20.2

NORMAL BRAKE SHOE PRESSURES: EMERGENCY

	Leading Truck	Rear Truck
Outside wheel	15,785 lb	16,090 lb.
Middle wheel	15,605 lb	15,555 lb.
Inside wheel	10,835 lb	9,840 lb.

Variation in normal brake shoe pressure = 6,250 lb.; per cent variation = 63.5

ACTUAL WHEEL PRESSURES ON RAIL: SERVICE

	Leading Truck	Rear Truck
Outside wheel	13,727 lb.	11,622 lb.
Middle wheel	10,697 lb.	11,826 lb.
Inside wheel	11,076 lb.	12,052 lb

Variation in wheel pressure on rail = 3030 lb.; per cent variation = 28.3

ACTUAL WHEEL PRESSURES ON RAIL: EMERGENCY

	Leading Truck	Rear Truck
Outside wheel	14,735 lb.	11,956 lb.
Middle wheel	9,816 lb.	11,234 lb.
Inside wheel	10,056 lb	11,435 lb.

Variation in wheel pressure on rail = 1,937 lb.; per cent variation = 50.3.

ACTUAL PERCENTAGE OF BRAKING POWER: SERVICE

Leading Truck

Outside wheel: $\frac{9155}{13727} \times 100 = 66.7$

Middle wheel: $\frac{9775}{10697} \times 100 = 91.4$

Inside wheel: $\frac{8130}{11076} \times 100 = 73.4$

Rear Truck

Outside wheel: $\frac{8825}{11622} \times 100 = 75.9$

Middle wheel: $\frac{9175}{11826} \times 100 = 77.6$

Inside wheel: $\frac{8215}{12052} \times 100 = 68.1$

Variation in percentage of braking power $= 91.4 - 66.7 = 24.7$.
Per cent variation in percentage of braking power $= \frac{24.7}{66.7} \times 100 = 37.0$.

FORCE EFFICIENCY OF BRAKE APPARATUS: SERVICE

For leading truck,

$$\frac{2 \times (9155+9775+8130)}{6 \times 9052.5} \times 100 = 99.6\%$$

For rear truck,

$$\frac{2 \times (8825+9175+8215)}{6 \times 9052.5} \times 100 = 96.5\%$$

FORCE EFFICIENCY OF CAR BRAKE, EXCLUSIVE OF CYLINDER LOSSES, ETC.: SERVICE

$$\frac{54120+52430}{2 \times 54315} \times 100 = 98.1\%$$

FORCE EFFICIENCY OF CAR BRAKE, INCLUDING ALL LOSSES

$$\frac{106550}{0.85 \times 142000} \times 100 = 88.3\%$$

ACTUAL PERCENTAGE OF BRAKING POWER: EMERGENCY

Leading Truck

Outside wheel: $\frac{15785}{14753} \times 100 = 106.9+$

Middle wheel: $\frac{15605}{9816} \times 100 = 159.1+$

Inside wheel: $\frac{10835}{10056} \times 100 = 107.7$

Rear Truck

Outside wheel: $\frac{16090}{11956} \times 100 = 134.6$

Middle wheel: $\frac{15555}{11234} \times 100 = 138.5$

Inside wheel: $\frac{9840}{11435} \times 100 = 86.1$

Variation in percentage of braking power $= 159.1 - 86.1 = 73.0$
Per cent variation in percentage of braking power $= \frac{73.0}{86.1} \times 100 = 84.8$

FORCE EFFICIENCY OF BRAKE APPARATUS

For leading truck,

$$2 \times \frac{(15785+15605+10835)}{6 \times 17040} \times 100 = 82.6\%$$

For rear truck,

$$2 \times \frac{(16090+15555+9840)}{6 \times 17040} \times 100 = 81.2\%$$

FORCE EFFICIENCY OF CAR BRAKE, EXCLUSIVE OF CYLINDER LOSSES, ETC.

$$\frac{84450+82970}{2 \times 102240} \times 100 = 81.9\%$$

FORCE EFFICIENCY OF CAR BRAKE, INCLUDING ALL LOSSES

$$\frac{167420}{1.60 \times 142000} \times 100 = 73.7\%$$

N. A. CAMPBELL.[1] After the Central Railroad of New Jersey high-speed brake tests in 1903, a relatively short time ago, it was thought that the last word had been said in high-speed braking. Stops were made from 60 miles per hour in less than 1000 ft. and until the Pennsylvania Railroad tests last year they had not been equalled. The locomotives and cars, however, were about half the weight of those now in use. The problem of braking the heavier modern cars so as to make the shortest possible stop in emergency applications has been a much more difficult one than that with which we were confronted ten years ago. Few fast passenger trains at that time averaged more than six cars in length or more than 500 tons including the locomotive. Trains of from 10 to 12 cars that weigh over 1000 tons, including the locomotive, have been a source of much trouble to some roads on account of the severe shocks and wheel sliding that resulted from emergency applications.

With the pneumatic brake, the brake cylinder pressure reaches the maximum on the forward portion of the train before the brakes have been applied on the rear. The result is that the slack has time to run in, causing a shock, more or less severe, according to conditions, and exerting a force against the forward portion of the train which has a tendency to cause slid flat wheels. Some railroad men have been protesting against the rapid rise of brake cylinder pressure in emergency applications. They said that they would prefer a slower rise of pressure in the cylinders and longer stops than the trouble due to shocks and slid flat wheels. They are justified in their complaint as far as the pneumatic brake is concerned, but I believe the electro-pneumatic brake will tend to overcome the trouble.

The use of the electric control in combination with an air brake equipment of more modern design, which has port areas sufficiently large to permit the maximum cylinder pressure to be obtained in less than half the time required by the older equipments, will very materially reduce the length of emergency stops.

However, as there are very many service stops made to one in emergency, it is just as important, if not more so, to take care of the service applications. The time required to make a service reduction of brake pipe pressure increases with the increased length of the train, and as the brakes are applied on the forward portion of the train before they are on the rear, causes shocks or surges. Electric control of the brakes causes the brakes on all cars to operate simultaneously, thus eliminating the cause of these shocks by eliminating the time element existing with pneumatic operation.

With the electro-pneumatic brake, even the indifferent or unskilled engineer can handle a long train as smoothly and accurately as a single car, while without the electric control

[1] Rep., N. Y. Air Brake Co., 165 Broadway, New York.

the careful and skilled engineer cannot always make a smooth, accurate stop, no matter how hard he tries.

THE AUTHOR. Wheel sliding, to which Mr. Vaughan refers, is perhaps one of the most elusive limitations to satisfactory brake operation. As Mr. Kelly explains, the factors involved in finally determining whether wheels slide or not in any given case are so numerous, complicated and oftentimes obscure that the assignment of a definite cause or causes or the adoption of practicable preventative measures, at the same time maintaining the desired brake effectiveness, is almost entirely a matter of judgment rather than of fixed rule.

The effect of flanged brake shoes as observed by Mr. Vaughan has been a more or less common experience on many roads in this country. On the other hand, a large railroad system in the East has used flanged brake shoes of a highly efficient type as standard on all their passenger cars for years. The cars are braked from the ordinary high-speed brake standard up to as high as 180 per cent braking power in emergency, trains being made up as the cars may come. This road has not experienced any inconvenience from wheel sliding under these conditions. As pointed out by Mr. Sargent and Mr. Burton it has sometimes been found that the brake rigging and brake head construction has been responsible for trouble experienced with flanged brake shoes. The use of worn shoes on new wheels has also been a cause of trouble.

There appears to be but one circumstance which can unhesitatingly be blamed for sliding wheels, namely, *an excess of resistance to rotation over rail adhesion.* The causes contributing to diminished rail adhesion or increased resistance to rotation are many and variable.

The considerable increase in train deceleration during the last few hundred feet before the stopping point is an evidence of the characteristic action of frictional resistance at constant pressure, when the speed of relative motion of the rubbing surface is being continually reduced from a relatively high value to zero. This phenomenon was first observed and commented upon in the report of the classical Galton-Westinghouse Brake Trials on the London, Brighton & South Coast Railroad in 1878 and 1879, and was at that time attributed to the effect of speed.

All subsequent experiments have developed this characteristic action. The present experiments as explained in the the paper show that it is, after all, a temperature effect, speed being one of the factors determining the resultant temperature of the working surfaces. This can be visually observed in the disappearance of sparking (showing a high temperature of the rubbing surfaces) and the appearance of non-incandescent brake shoe metal ground off toward the end of the stop. Invariably the cessation of sparks and appearance of the non-incandescent metal dust are coincident with the beginning of the rise in the deceleration line referred to by Mr. Vaughan.

The question of complication mentioned by Mr. Vaughan and Mr. Thomson depends largely on the functions demanded of the brake. If simple and moderate functional performance can serve the purpose, complication of apparatus can largely be dispensed with. But if a multiplicity of functions, a high degree of protection against undesired action, and a high efficiency and effectiveness are demanded a certain amount of elaboration of the apparatus is necessarily implied. Mr. Turner has pointed out the requirements of modern railroad service which are constantly demanding more and more of the brakes along these lines.

It might be suggested here that the impression of complication is heightened by the multiplicity of lines required to illustrate the sequence and connections of the working parts of the valve device diagrammatically, and as if all in one plane. This by no means indicates an undue complexity of the device itself, however, partly because in the actual construction the connections can be made much more direct and simple than on a single flat surface and partly because ports and passageways once properly fixed in the metal do not create in fact the working complication suggested by the lines on the drawings.

The New York, West Chester & Boston tests mentioned by Mr. Potter are probably the best comparison of the action of one and two brake shoes per wheel which we have on record up to date. This is because the rigging effect was practically eliminated by reason of the use of the same rigging (with proper adjustment) for the single shoe tests as was used for the tests with two shoes per wheel. Thus, the tests fairly compare the action of one shoe with that of two shoes per wheel, without introducing the additional uncertainty of the action of two different types of foundation brake gear which is always present when testing differently designed riggings for clasp and for single shoe brake equipment.

With reference to the cause of the variation in train records mentioned by Mr. Sargent we would refer to the section on Check Runs and Averages, where it is shown that the length of stop varied from 1049 ft. to 1389 ft. No assignable cause for this variation has been discovered aside from the known difference in brake shoe bearing and shoe temperature. It therefore seems fair to assume that the different shoe metal conditions resulting from the different manipulations of the test train were capable of producing the differences observed. Moreover, by the same manipulation the same variation in the results could be reproduced at will.

The data submitted by Mr. Burton on braking force and wheel pressures disclose conditions of the greatest importance and significance. This phase of the situation deserves the careful consideration of all having to do with the design and maintenance of brakes and foundation brake rigging.

The per cent difference in stopping distance deduced by Mr. Burton requires a word of caution to prevent misunderstanding or misuse.

For electro-pneumatic brake operation the almost instantaneous application of the brakes makes it permissible to assume, as Mr. Burton has done, that the stops will vary inversely as the product of $e \times f_s$. But on account of the longer time occupied in reaching full effectiveness with pneumatic operation and especially if the performance of the PM brake equipment is being considered ($t = 2.5$ for PM equipment) more or less error is involved if the same assumption is made in such cases. The stops with the PM brake equipment, for instance, would all be longer than those on which the table was based and the influence of the time element (t in the formula given in the paper for length of stop) could no longer be disregarded as is the case when the stops are assumed to be inversely proportional to $e \times f_s$.

MEETINGS

SAN FRANCISCO, SEPTEMBER 10

The San Francisco Section held a quarterly meeting on September 10, at which a lecture by John A. Britton on the Lake Spaulding Dam of the drum hydroelectric installation recently put in service. This dam is at present 235 feet high and will ultimately be raised to 305 feet. The lecture was presented by H. C. Vensano and J. Jollyman discussed the mechanical and electrical features.

CINCINNATI, SEPTEMBER 17

A meeting of the Cincinnati Section was held on September 17, the address of the evening being upon the subject of Electrical Wires and Cables, given by Charles R. Sturdevant of Worcester, Mass., connected with the engineering and educational departments of the American Steel & Wire Company. The speaker laid special emphasis upon insulating materials, explaining at length how the three materials commonly used for insulating electrical wires and cables, viz., rubber compound, saturated paper and varnished cloth, are made and how they are applied, and how these in general need further protection by braiding, sheathing, or armor. It was further shown how the finished cables are tested, the effect of heat upon the electrical properties, and the energy losses in cables in service. Mr. Sturdevant showed an unusually fine collection of samples of these cables in which the audience was much interested.

PHILADELPHIA, OCTOBER 8

A joint meeting with the Franklin Institute was held by the Philadelphia members in the hall of the Institute on October 8, with a paper by J. E. Johnson, Jr., of New York, on Recent Developments in Cast Iron Manufacture. Mr. Johnson discussed the general results of carbon, silicon, sulphur, phosphorus, oxygen and manganese in cast iron. In connection with carbon, he considered particularly the effect of the shape of the crystals and the form of crystallization, which are not shown in the iron-carbon diagram. He outlined investigations made at the Ashland plant of the Lake Superior Iron and Chemical Company, in which it was disclosed that the presence of oxygen accounted for the superiority of charcoal iron over coke iron. He further described experiments made to introduce oxygen and convert coke iron into a product he considered superior to charcoal iron, and gave the physical properties of an iron of the composition of combined carbon, 0.85 per cent, graphitic carbon, 2.65, manganese, 0.26, phosphorus, 0.326, sulphur, 0.039, silicon, 1.25, oxygen, 0.50. Photomicrographs of the structure of this iron were shown.

A discussion of the paper followed.

BOSTON, OCTOBER 14

The first meeting for the season in Boston was held on October 14, the subject of the evening being Means and Methods of Measuring the Flow of Fluids in their Application to Industrial and Engineering Problems.

Three types of apparatus in most common use in connection with the handling of water, oil, steam, gas, etc., were described, Frederick N. Connet, chief engineer, Venturi Department, Builders Iron Foundry of Providence, describing the Venturi Type; E. L. Brown of the General Electric Company, Boston, dealt with the Pitot Type; and D. R. Yarnall, treasurer, Yarnall-Waring Company, Philadelphia, took up the Weir Type. The remarks of all three were illustrated with lantern slides.

Mr. Connet presented a chart showing the development of the study of hydraulics and the theory of freely falling bodies, tracing it back to the time of Leonardo da Vinci, about the year 1500. He showed that to Toricelli belongs the credit for the formula, V varies as the $\sqrt{H}$, and to Bernouilli, about the year 1700, is ascribed the establishment of the formula, $V = \sqrt{2GH}$. The principle of the venturi meter was brought out by Venturi in about 1800 and Herschel later adapted this principle into the venturi meter itself, giving it its present name. The slides shown by Mr. Connet displayed meters all the way from $1\frac{1}{2}$ in. to $17\frac{1}{2}$ ft. in diameter and also the 36-in. meters used at the World's Fair in 1893, by the use of which a large and unexpected leakage was checked. He called special attention to the fact that pulsations must be removed and showed methods for overcoming this difficulty.

E. L. Brown devoted his remarks to the flow meter of the pitot type extensively used for measuring the volume of steam.

D. R. Yarnall described the Lea V-notch recorders, both single and combined with feedwater heaters, and explained that the principle of operation was based on Thompson's formula for the V-notch. Methods of computing from the records made by the instrument were described. He called attention to the use of blowdown meters, the readings from which are to be deducted from those of the supply meters to show the net evaporation. These meters are used in a big plant to indicate any leaky blow-off valves.

In the discussion which followed, R. E. Dillon described a St. John orifice meter and J. F. Vaughan gave experiences with meters that had come under his observation. Sanford A. Moss dealt with the measurement of the volume of air issuing from blowers, air compressors, etc. About 150 were in attendance.

CINCINNATI, OCTOBER 15

Prof. F. R. Hutton addressed the joint meeting of the Engineers Club and the Cincinnati Section of the Society on October 15, upon the Testing of the Motor Vehicle. He urged among other things the abandonment of the word automobile and the substitution of the more inclusive term motor vehicle. His address covered four main points, the reason for testing a motor vehicle, where and by whom such tests should be made, how the motor-vehicle engines should be tested, and what results might be obtained from such tests.

A motor is tested for economy and efficiency, and may be tested on the road or on power measuring apparatus within doors; it may be tested by its designer and builder when new, or by its owner after it has been in use.

Professor Hutton illustrated the ways of testing by a large number of lantern slides, showing one of the best testing installations of the world, at the Automobile Club of America. A number of curves were given showing the plotting of the results of scientific testing. He made also a plea for good roads, illustrating bad roads by slides. There were more than 100 in attendance.

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

The war in Europe appears to have less influence on the files of papers at the Library of the Engineering Societies than was feared would be the case a month ago. Only a few German papers of minor influence have entirely suspended publication, and, of course, all the Belgian papers. The rest are appearing, though usually in a reduced size. The delivery appears also to have attained a considerable amount of regularity, so that there is now absolutely no doubt of the ability to maintain the Engineering Survey at the usual level of interest.

The greater engineering societies throughout Europe continue their activities. The German and Austrian Societies, in addition to purely engineering work, have gone into work of political and military nature. Thus, the Verein deutscher Ingenieure is recruiting engineers for the army, while the German Society of Steel Metallurgy is publishing and sending out with its official organ, reprints of telegrams from the seat of war, in German and English, purporting to present the true state of affairs from the German side.

THIS MONTH'S ARTICLES

The difficulties of manufacturing double acting two stroke cycle engines are presented in an abstract of an article by Hoffman in the section Internal Combustion Engineering. In the next section are indicated some data concerning the use of high speed tool steel and testing compressed air twist drills in German shipyards.

The article of Kaemmerer on auxiliary machinery aboard merchant ships, only part of which is abstracted here, covers several subjects of interest, such as the description of a new winch, evaporator, ball bearing, roller bearing, and a governor which is claimed to eliminate racing of the engine. In the same section will be found an abstract of an article by Loewe on the calculation of worm gear drives for the rear axles of power wagons. While this article does not present anything particularly new, it is given here because of the comparative scarcity of data on worm gear driving.

The article on steam and gas fired bakers' ovens by Pradel covers a somewhat neglected section of engineering to which the recent Gas Exhibition in Munich has given a considerable impetus in Germany.

The section on Steam Engineering contains several articles of interest. On account of lack of space only a brief reference could be given to the description of the boiler plant at the International Exhibition of Printing and Graphic Arts at Leipzig designed to burn exclusively lignite briquettes. In the next abstract Winkelmann discusses the influence of firing-up processes on the life of tubular boilers with withdrawable smoke-tubes, and various ways of preventing the rise of stresses due to difference between the temperature of water and boiler metal. Schömberg gives data on the application of large straight flow steam engines in metallurgical plants, chiefly in various types of rolling mills.

In the section Strength of Materials and Materials of Construction, are reported articles on the influence of the presence of notches on the strength of machine parts. In the course of this article mention is made of the work of Doctor of Engineering Preuss. We are sorry to announce that this writer, whose work has been referred to before in the Engineering Survey, has been recently killed in the war in Europe. In the next article in the same section, Weiss, in investigating the process taking place in upsetting of metal cylinders, calls attention to a rather striking phenomenon, viz., the formation of an internal core and an external ring surface, the appearance of latter, especially in the case of copper-manganese alloy, being essentially different from the core metal.

In a paper before the American Institute of Mining Engineers S. S. Rumsey and W. F. Schwedes describe a test of centrifugal motor-driven pumps.

An abstract of papers presented before the Engineers' Society of Western Pennsylvania on the measurement of the velocity of flowing water was given in the Engineering Survey for last month. These papers have led to a discussion of unusual interest, an abstract of which is given this month. An abstract of another paper presented before the same society, by C. L. W. Trinks on air in jet condensers, is likewise given this month, with such portions of the discussion as the space available permitted of using.

Of the papers presented to the autumn meeting of the Iron and Steel Institute abstracts are given of three papers of interest to the mechanical engineer: the decarburization of steel in the salt baths used for heating previous to hardening, where it is shown that a mixture is available which secures a perfect equilibrium, with respect to carbon in the bath, to such an extent that it is possible to obtain simultaneously, in the same bath, the decarburization of hard steels and the carburization of dead-soft steels. Walter L. Johnson, in a paper on the utilization of heat contained in slags in steam turbines, shows that while blades are available which are but little affected by steam produced from the hot slags, the direct method of steam utilization is not convenient on account of the tendency of sulphur deposit to clog the turbine passages, and a water heater or heat exchanger has to be used. He found that with proper equipment and without a heavy increase of cost of operation or initial investment, there may be obtained 31.6 h.p. per hour per ton of slag per hour. In this connection will be also of interest the paper by T. Rolland Wollaston before the Society of Chemical Industry on power costs in various works, showing that it is actually possible not only to obtain power free of cost, but to have a profit of 21 per cent on the capital outlay. This is possible with a Mond system peat gas recovery plant, the disadvantage of which is, however, that its capital cost is extremely high, approximately $210,000 for a plant of 2,000 h.p. There may yet come a day when all power used by the industries will be only a by-product of manufactures, chemical works, blast furnaces, coal products utilization, etc.

In connection with the abstract from the Professional Memoirs, Corps of Engineers, U. S. Army, in the October

issue of *The Journal*, p. 201, describing a type of rope fastening, Mr. F. W. Trabold, member of the Society, writes that he has found the drop-forged wire rope socket with the strands of the cable separated and then babbited to be a reliable type of construction. With the strongest wire rope the cables almost invariably parted before the sockets did, sometimes close to the socket, and sometimes at a considerable distance from it, which is of interest as the separation of the rope at some constant point might indicate weakness created in the given portion of the rope through the particular construction of the socket. As regards the comparative cost of splicing and babbiting, the writer points out that the labor of splicing is considerably more costly than that of babbiting the cable in the socket; while the socket itself is considerably more costly than the thimble, there is a final economy owing to the lower labor cost. Further, while the socket is more costly than the clip and thimble combined used in the splicing method, in the latter 18 in. additional cable is required which practically equalizes the matter of cost. As regards the strength of drop-forged wire rope sockets the writer states that with alloy steel plugs the socket on the $1\frac{1}{4}$ in. size pulled strains of 149,700 lb. without injury.

FOREIGN REVIEW

Internal-Combustion Engineering

Remarks Concerning Double Acting Two Stroke Cycle Engines (*Bemerkungen über doppelwirkende Zweitaktmotoren*, Max Hofmann, *Dinglers polytechnisches Journal*, vol. 329, no. 38-39, p. 575, September 26, 1914, 3 pp., 3 figs., *g.*). The article discusses the difficulties of design and construction of double acting two-stroke cycle engines. It is not sufficiently realized, according to the author, that the main essential requirements of this type of engine, that, commercially, it can be built only in large sizes—is opposed by the difficulty of overcoming the stresses caused in the large cylinder castings by expansion due to unequal heating. A complicated engine cylinder in which the liner and cooling water jacket are cast in one piece and which carries on top and bottom, a second jacket for the scavenger air connections, is just the kind of construction that is likely to show cracks in it immediately after it is set in operation. The jackets by no means increase the strength of the cylinder in the axial direction. On the contrary, the working walls of the cylinder come in contact with the burning gases and attain a high average temperature while the exterior jacket, on account of the flow of water, remains cool, this combination leading to the rise of great axial stresses and possible rupture of the cylinder. It has been recommended to use special liners or to put in, either by threading or by rolling in, special steel tubing for scavenger air valve support. This is, however, not mechanically convenient, since the heat expansion of the liner and the displacement of the threaded-in or rolled-in connection would very rapidly develop leaks at places.

The design of scavenger valves is also a difficult problem. Horizontal valves are only used seldom, the Körting type being the only one on the market. In order to obtain a disc-shaped combustion space, this type is willing to suffer the operating difficulties of this type of valve arrangement. With it, the scavenger valve pockets have to be so deep as to raise very materially the clearance space at the end of the compression stroke. As shown in Fig. 1 (upper connection-admission of scavenging air, lower connection for exhaust), the double acting engine of this type gives approximately 20 per cent of the combustion space to pockets necessitated by the horizontal valve arrangement and since the piston in its final position covers over these pockets to a large extent, the air contained therein is late in coming in contact with the entering fuel, and is apt therefore to produce after-burning of the charge, in addition to which the horizontal position of the valve is apt to produce incomplete scavenging.

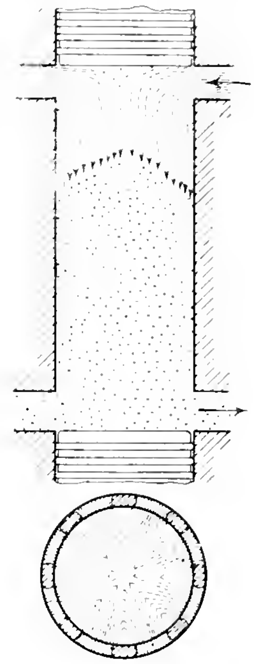
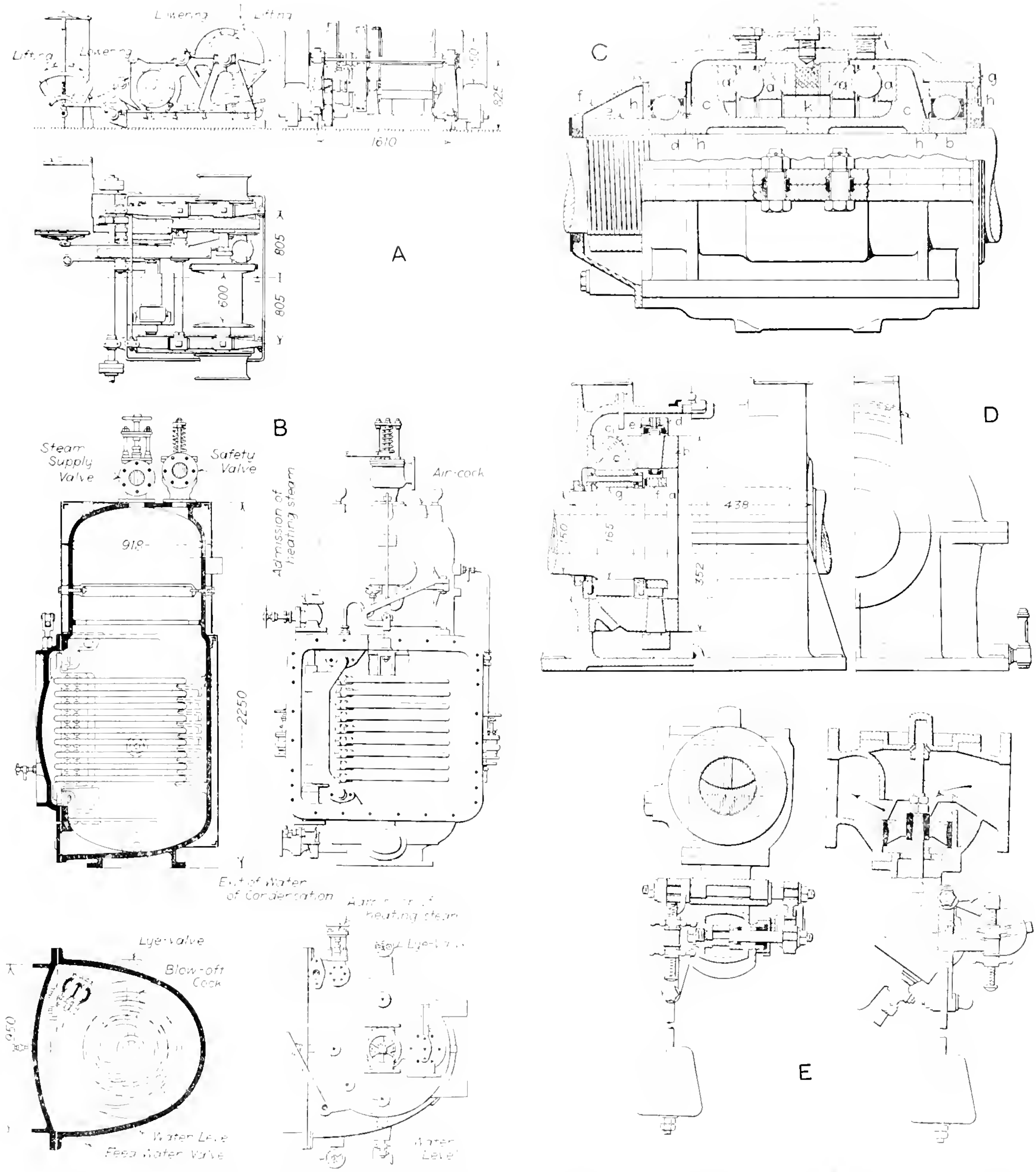


Fig. 1 Double Acting Two Stroke Cycle Engine Cylinder

Machine Shop

Testing of Compressed Air Twist Drills in the Royal Shipyards at Kiel (*Erprobung von Spiralbohrern für den Pressluftbetrieb auf der Kaiserlichen Werft Kiel*, T. Schwarz, *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 33, p. 1336, August 15, 1914, 4 pp., 6 figs., *de.*). The article presents a description of an installation for the purpose of testing twist drills, and indicates how from the data of such tests one is enabled to determine the most advantageous grades of steel for the various kinds of work. Until the time when twist drills have been produced from high speed steel, the latter had quite a limited application in shipyards. Even now, in the case of high speed steel, one has to consider not only the price of the material, but also its range of application. While high speed steel has been proven capable of excellent work for drilling purposes, it seems to be far less applicable for dies and stamps for compressed air riveting. Further, the number of grades of high speed steel used in shipyards increases rapidly with the range of application, and since each grade of steel requires the use of peculiar methods for its handling and hardening, the proper selection of tool steels becomes a matter of considerable difficulty. The further difficulty of buying these supplies for government shipyards by open competition led to the development of a system of ordering tool steel by indicating the purpose for which it was to be used.



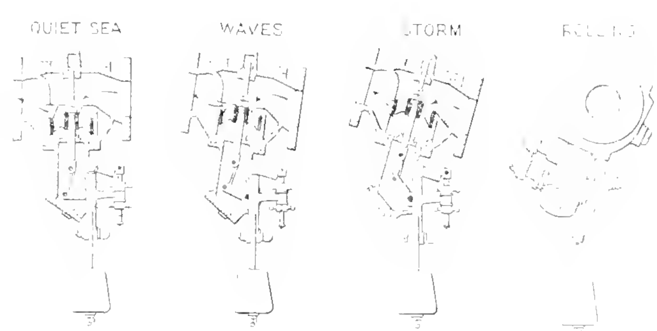


FIG. 2 MERCHANT SHIP MECHANICAL EQUIPMENT: *A* WINCH; *B* EVAPORATOR; *C* BALL BEARING; *D* ROLLER BEARING; *E* BROUQUIERE GOVERNOR

This is particularly the case with twist drills which have been found to have a very wide application in shipyards on compressed air drilling machinery, and this makes the output test recently conducted at the Royal shipyard in Kiel of particular interest. All the twist drills used for these tests have been made of high speed steel, 17 mm. in diameter. They were all delivered by the manufacturers at the shipyards ready for use, only provided with one angle of 116

deg. The article shows the arrangement of the testing apparatus and gives the data obtained in the tests, among other things curves of output for various types of high speed steel twist drills.

Modern Auxiliary Machinery and Installations on Merchant Ships (*Neuere Hilfsmaschinen und Einrichtungen für Handelsschiffe*), W. Kaemmerer. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, serial, *d.i.* The article describes modern auxiliary machinery and installations on a merchant ship. Among other things described is a special winch for use on boats to serve simultaneously for hoisting provisions, coal and boats. It is shown in Fig. 2A and is operated by a 24 h.p. 200 ampere 110 volt direct-current motor, driving at 590 r.p.m. the main shaft of the winch which serves for hoisting provisions. On an extension of the shaft, there is a capstan head to take care of the coal baskets; further, there is a train of two spur gears, driving at 700 r.p.m. a transmission shaft for the Welin boat davits. The handling of the winch is extremely simple. The load is lifted by a single hand lever, while a foot lever actuates a braking electric magnet. The winch lifts a load of 2 tons at a speed of 0.75 meters (29.5 in.) per second.

The author describes further an evaporator (Fig. B) which is said not to have been previously described anywhere. It has a heating area of 5.9 q.m. (63.5 sq. ft.). The sea water enters at *a* and flows around the copper serpentine *b*, through which passes the steam from the boilers or receivers. The salt deposited during the above operation is let out through a valve *c*; steam obtained from the sea water moves forward and is let out through the valve *d*. In the upper part of the condenser there is a preheater and trap *e*, the purpose of which is to eliminate from the steam the water particles. The copper serpentine can be easily taken out by removing a single cover and easily cleaned, which would be necessary quite often as the salt has a tendency to deposit on the copper.

Fig. C shows a pressure bearing designed for propeller shafts by the German Arms and Ammunition Factory in Berlin. Its construction is characteristic through the fact that both the radial and axial pressure on the shaft is taken up by ball bearings. The ball bearing *a* is placed in a strong housing of steel casting reinforced by ribs in which the races are adjusted on both sides. One ball race bearing *b* presses on one side against a shoulder on the shaft and on the other hand is held by a divided intermediary piece. The other ball race bearing *d* presses against the intermediary piece by a nut *e*. After the cap-shaped cover *f*, placed on top, is removed, the housing becomes easily accessible. On the other side, the housing is closed by an ordinary flat cover. Both covers are packed with respect to the shaft by felt rings. The balls are held in the bearings by the casings *h* made of brass; both footstep bearings *a*, kept in place by the intermediary piece *c*, are provided with foot rings pressing against the base plate *i*, and have automatic adjustment to meet bending of the shaft. From the base plate, the footstep pressure is transmitted by means of the intermediary ring *k* held rigid in the housing. On the side free of load there is an air gap of 0.25 mm. (0.009 in.) between the base plate and the intermediary ring. The base plate also takes up the pressure of a number of vertical spiral springs uniformly distributed around the periphery. The balls of the bearings are held in casings of sheet brass. The oil used for lubrication must have such a high level in the bearing that the balls in the races should be under oil up to one half. This can be observed from the outside by means of glass tubes. The balls of the fundamental bearing run also constantly in oil. The axial pressure taken up by such ball bearings amounts to 800 kg. (1763 lb.) at 150 r.p.m.

The roller bearing of the Moffet type to take up axial pressure of the propeller shaft, as built by the Atlas works at Bremen, is shown in Fig. D. The pressure shaft has only one connection *a* over which is placed, on each side, a hardened ground ring *b* to take up the alternations in the direction of the pressure during the forward and backward motion. From these two rings the pressure is transmitted upon a special bearing by means of a number of conical rollers, either in one direction or another, through two spherical rings *c* and *c'*, gripping into one another. The conical rollers are held in a rigid casing *d* on both sides of the cam, but each roller is individually adjustable by means of the device shown at *e*. Each of the roller casings is steered along the shaft by means of a bronze ring *f*, while the weight of the pressure shaft itself is taken up by the cylindrical rollers *g*, which in their turn, are located in a rigid frame. Small bolts are used for guiding the individual rollers along the shaft, provided with such an amount of play that they do not take part in the transmission of the pressure.

The article further describes the construction of the Brouquière governor, the advantage of which is that it is claimed not to permit racing of the engine. Its construction is said to be extremely simple and is shown in Fig. E. As close as possible to the valve of the pressure cylinder, is built in the steam piping, a special governor valve, the housing of which (made of bronze, cast iron or cast steel), contains a cylindrical guide with slots. These slots, and consequently the steam admission to the engine, are opened or closed as necessary, by means of a piston rod which, as shown in Fig. F, is moved in such a manner that as soon as the level of the ship changes longitudinally, a pendulum begins to act on a knee lever transmission, this action taking place, however, only when the ship changes its position in a longitudinal direction; if the ship starts to roll, the pendulum oscillates without affecting the steam stop valve, the position of which may be further adjusted by means of a special spindle. The action of the governor may be seen from Fig. G.

Mechanics

Calculation of Worm Gear Drive for Rear Axles of Power Wagons (*Berechnung des Schneckenantribes für Kraftwagen-Hinterachsen*, A. G. von Loewe. *Der Motorwagen*, vol. 17, no. 21, p. 501, July 31, 1914, 4 pp., *mp.*). In calculating the worm gear drive for the rear axles of power wagons, the gear ratio $\ddot{U}$ and the normal modulus may be assumed to be known. The following conditions must be satisfied by the worm gear drive: (1) a very high efficiency, in good execution about 97 per cent; (2) possibility of reversing without materially increasing the work of friction; (3) no danger of seizing between surfaces sliding under pressure. The fulfillment of these conditions is affected principally by the angle of inclination of the worm, the selection of which must be therefore made with the greatest care. To determine the efficiency, and consequently the friction losses, one has to start from the conditions of equilibrium of the worm gear drive. Let A_m = the work of driving, A_r = work of friction, A_t = work transmitted; then:

$$A_m = A_r + A_f \text{ and } A_r = A_m - A_f.$$

If α is the angle between the thread and the generating line of the cylinder of the gear, and $\mu = \tan \varphi$ the coefficient of friction, then:

$$A_f = \frac{A_m}{\sin\alpha} \cdot \frac{\mu}{\cos\alpha + \mu \sin\alpha}$$

$$A_r = A_m \frac{\mu(1 + \tan^2\alpha)}{\tan\alpha(1 + \mu\tan\alpha)}$$

The efficiency η is:

$$\eta = \frac{A_r}{A_m} = \frac{\tan\alpha - \mu}{\tan\alpha(1 + \mu\tan\alpha)}$$

By differentiating this expression in α, we find that η is a maximum when

$$\mu(1 + 2\mu\tan\alpha - \tan^2\alpha) = 0$$

and hence:

$$\tan\alpha = \mu \pm \sqrt{\mu^2 + 1}$$

If we substitute for μ in this expression some number C, and then determine the value of α, it will always be, provided $\mu = \tan\alpha$,

$$\alpha = 45^\circ + \frac{C}{2}$$

and therefore the best efficiency will be obtained from a worm and worm-wheel with an angle of inclination:

$$\alpha = 45^\circ + \frac{C}{2}, \text{ or } \alpha' = 45^\circ - \frac{C}{2}$$

In the case of motor cars such wheels cannot be applied, however, because their diameter is approximately proportional to the gear ratio, and the drive would therefore have too large dimensions. When the angle of inclination is $45^\circ - \frac{C}{2}$ the friction in reversed drive is approximately equal to that of direct drive; the smaller the angle α, the larger are the friction losses in reverse drive, until at $\tan\alpha = \mu$ seizing takes place.

According to data collected by Ader for the *Automobiltechnisches Handbuch*, there is the following relation between the admissible normal tooth pressure P_n (in kg.) and the sliding speed v_g (in meters per sec.):

v_g	1.25	2	2.5	3	4
P_n	600	375	300	240	150

In the same reference book a table is given which indicates that the greater the number of turns of the worm, the smaller are the friction losses in the worm gear drive.

The forces acting in the gear are determined in the following manner. The following notation is used:

M_m the maximum moment of torsion transmitted in kg. per cm.;

d diameter of pitch circle of worm, in cm.;

P tangential pressure at the pitch circle of the worm, in m. per kg.;

P_1 transmitted tangential effort at the pitch circle of the worm wheel in m. per kg.;

P_n normal tooth pressure in kg.;

α angle of inclination in deg.;

μ coefficient of friction;

η efficiency of the worm gear drive;

If the worm drives the gear,

$$P = 2\frac{M_m}{d}$$

where d can be determined graphically. Further:

$$P_1 = P\frac{\tan\alpha - \mu}{1 + \mu\tan\alpha}, \text{ or } P_1 = P\frac{\tan\alpha - 0{,}08}{1 + 0{,}08\tan\alpha}$$

the latter with $\mu = 0{,}08$. The normal tooth pressure is

$$P_n = \frac{P}{\cos\alpha - \mu\sin\alpha} \text{ and } P_n = \frac{P}{\cos\alpha - 0{,}08\sin\alpha}$$

the efficiency is then:

$$\eta = \frac{\tan\alpha - 0{,}08}{\tan\alpha(1 + 0{,}08\tan\alpha)} \text{ and } \eta = \frac{\tan\alpha - 0{,}08}{\tan\alpha + 0{,}08\tan^2\alpha}$$

In order to determine the permissible tooth pressure as a function of the sliding speed, the pressure at the greatest sliding speed that may occur has to be determined, since, as shown in the above table, with increasing sliding speed, the pressures P_n invariably decrease, while the moment of torsion is inversely proportional to the speed of rotation. The greatest sliding speed occurs when the worm runs at the speed n of the engine. The tangential pressure which then occurs at the pitch circle of the worm is:

$$P_1 = 2\frac{M}{d},$$

where M is the moment of torsion of the engine. The normal tooth pressure is then:

$$P_n = \frac{P_1}{\cos\alpha - 0{,}08\sin\alpha}$$

The maximum tangential speed at the pitch circle of the worm is:

$$v = \frac{\pi d.N}{100.60} = \frac{d.N}{3600} \text{ meters per sec.,}$$

where N is the highest speed of the engine. The sliding speed is

$$v_g = \frac{v}{\sin\alpha}$$

The values of P_n and v_g must satisfy the requirements of the table. A similar calculation must be carried out also for a reversed drive under the above most unfavorable assumptions. Let P'_1 be the tangential resistance to be overcome at the pitch circle of the worm, in kg.;

P' tangential pressure at the pitch circle of the worm wheel, in kg.;

P'_n normal tooth pressure in kg.;

M moment of torsion of the engine in cm. per kg.; then the following relations are good:

$$P'_1 = \frac{2 \cdot 0{,}65\, m}{d} = 1.3\frac{M}{d}$$

$$P' = P'_1\frac{\tan\alpha + \mu}{1 - \mu\tan\alpha}, \text{ and } P' = P'_1\frac{\tan\alpha + 0.1}{1 - 0.1\tan\alpha}$$

and the normal tooth pressure is

$$P'_n = \frac{P'}{\sin\alpha + \mu\cos\alpha} \text{ and } P'_n = \frac{P'}{\sin\alpha + 0.1\cos\alpha}$$

the efficiency being:

$$\eta' = \frac{\tan\alpha(1 - \mu\tan\alpha)}{\tan\alpha + \mu} \text{ and } \eta' = \frac{\tan\alpha(1 - 0.1\tan\alpha)}{\tan\alpha + 0.1}$$

Since in the case of reversed drive the relation between resistance (or tooth pressure) and speed of rotation (or sliding speed) are different from that in the case of direct drive, and there is no apparent proportionality between the two, it is necessary to determine it for the two extreme cases, that is, maximum normal tooth pressure and maximum sliding speed. In the first case $P'_1 = P'_n$, and

$$v' = 1.5\frac{z_1 z_2 . N . d.}{Z_1 Z_2 . 3{,}00} \text{ meters per sec.,}$$

where z_1, z_2, Z_1, Z_2 are the numbers of teeth of the driving wheels in engagement at the smallest gear ratio.

$$v'_g = \frac{v'}{\sin \alpha}$$

At the greatest sliding speed the resistance at the pitch circle of the worm is:

$$P'_u = 0.2 \cdot 2\frac{M}{d} = 0.4\frac{M}{d}$$

and the tangential pressure at the pitch circle of the worm wheel is

$$P'_o = P' \frac{\tan \alpha + 0.1}{1 - 0.1 \tan \alpha}$$

Hence the normal tooth pressure is:

$$P'_{on} = \frac{P'_o}{\sin \alpha + 0.1 \cos \alpha}$$

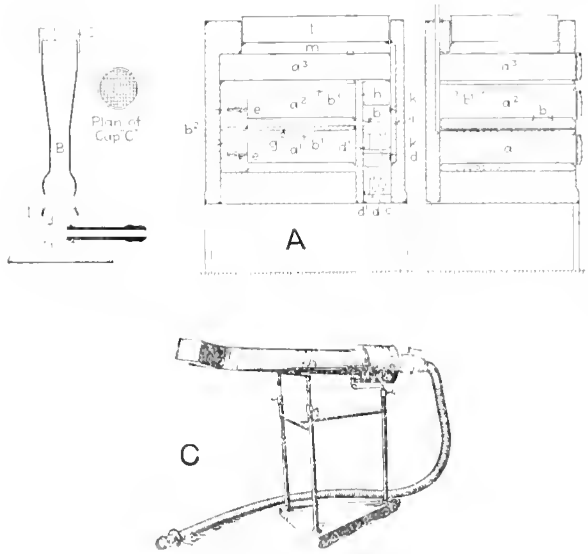
and the sliding speed appears to be equal to

$$v_g = \frac{v}{\sin \alpha}.$$

From this the author proceeds to the determination of various dimensions of the worm gear drive.

Ovens

Steam and Gas Fired Bakers' Ovens (*Dampf- und Gasbackofen*, Pradel, *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 38, p. 435, September 18, 1914, 3 pp., 11 figs., *d.*). The article describes various types of modern steam heated and gas fired bakers' ovens, mainly those shown at the recent Gas Exhibition in Munich, Germany. After giving a general statement of the principles on which the construction of this kind of bakers' oven is based, the author describes several types of such ovens. Of late, gas firing was applied to steam heated bakers' ovens, e.g., in the Senking type of oven. It was constructed mainly for use in small bakeries. As shown in Figures 3 A and B, the Senking oven consists in the downward direction of four double walls and in the lateral of two double walls, insulated so as to prevent losses through heat radiation. In order to save floor space, the oven is built vertically and has from 2 to 6 decks, one over the other. This arrangement is of particular advantage for large cities where floor space considerations are of importance. Figs. A and B show two sections of a 3-decks oven at right angles to one another. Fig. C shows a similar 6-decks oven which gives an idea of the oven equipment. The oven is constructed in such a manner that each deck singly and all the decks together may be operated as desired. These single decks are accessible through doors *f*. When a 3-decks oven is used, two systems of piping are employed one in each of the two lower decks, a and a^2, divided from one another by means of the wall g and from the heating space by the wall h. Through this latter wall pass the ends of the steam pipes b which have to be heated. The heating pipes are U-shaped and are located in such a manner that their lower bend lies on the floor of the decks under the drawplate, while the upper bend b_1, which joins the upper bend b_1, goes under the deck cover nearly to the wall h. The decks a_1 and a_2 are therefore provided with heat from above and from below, while the deck a is provided only with heat from below. As a rule, all appliances on the oven, as well as the gas cocks, are placed as far as possible on the front part so that the attendance may be easy and convenient. In the heating space of the oven between the wall h and the external wall are located the gas pipes for the different decks operated by cocks placed on the outside. The air of combustion enters from below out of the air chambers d and reaches the flame through the openings d_1, while a supplementary amount is admitted through the screen doors which serve for igniting the gas and for cleaning.



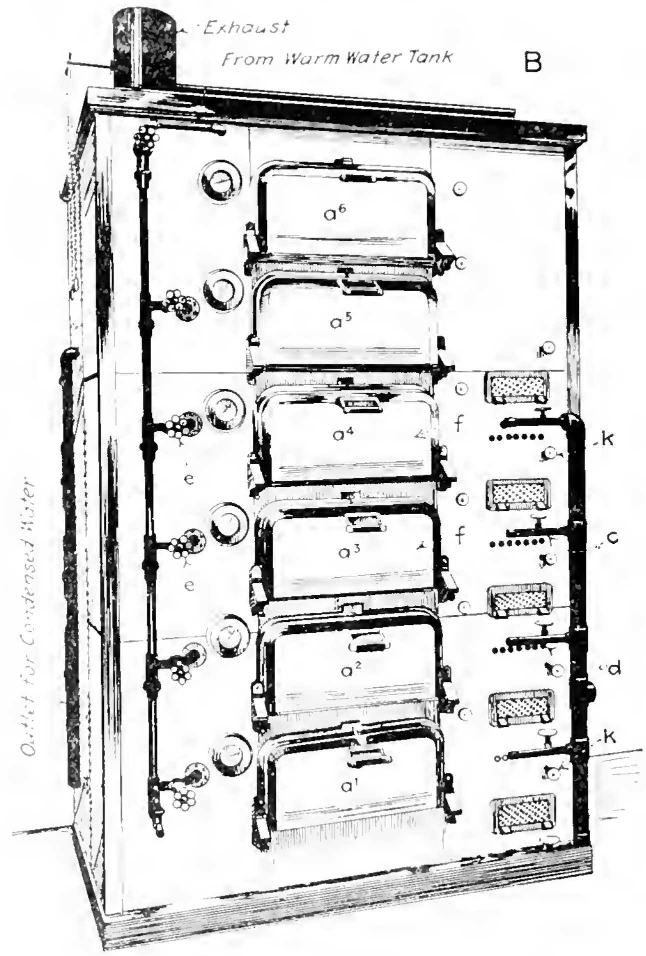


Fig. 3 Bakers' Ovens and Heaters for Same

As the combustion of gaseous fuels can be regulated in

such a manner as to produce a flame free from soot, indirect heating of baking ovens by gas does not appear to be necessary, and the oven may be heated by the gas flame direct. It is possible therefore to easily convert a wood fired oven into a gas oven by simply using a suitable burner. The Méker burner used in this connection is really nothing but an improved Bunsen burner. Fig. D. It consists of a pipe through which the gas is driven by the injector *I*, provided with a calibrated opening. Over this injector is screwed the chimney *D*, provided at the bottom with holes, and closed at the top by a cellular body *C*, perforated by passages and having the purpose of preventing backfiring and also of producing a uniform flame. As shown in Fig. E, the nozzle of the burner is forked, in order to allow the flame to play over the entire width of the oven. The burner is made of heavy steel sheeting and welded autogenously so as to leave no spaces which are not gas tight. The cellular body *C* is made of nickel-steel strips. The burner is supported on a wheel truck and connected with the gas piping by metal hose so that it can be pushed into the oven when the fire is started and taken out again. The question whether several smaller or one large gas fired oven is more economical is as yet undecided and experimental data are lacking. In view of the easy attendance on a gas fired baking oven and its simplicity, however, it would appear that a larger number of small ovens would in the end prove more economical for large outputs than one large one. An oven of which the author holds a high opinion has been shown at the Exhibition. In order to obtain as uniform heating in the entire oven space as possible, the burner is built in along the three sides of the oven space; viz., by the side of the superimposed deck plates and below the lowest plates. In this way the properties of gas heating are said to be especially well utilized and the heat conducted directly where it is most useful. The article goes into some detail of this construction, but does not illustrate it.

Pumps

Oil Driven Engine-Pump Aggregate (*Groupe motopompefonctionnant au pétrole, Portefeuille économique des machines*, vol. 2, series 6, no. 702, p. 81, June 1914, 2 pp., 2 sheets of drawings. *d*). The article describes a direct-connected aggregate of a motor and pump, the motor being a four cylinder shale-oil engine, 130 mm (5.1 in.) bore and 160 mm (6.2 in.) stroke, developing at 1000 r.p.m. about 41 h.p. The motor is provided with an Aster carbureter heated by the exhaust gases, and high tension Bosch magneto ignition. For special reasons it was desirable to have the aggregate occupy as little space as possible. As however the pump ran at 450 r.p.m. a reduction of speed was necessary, but as there was no room for extending the motor shaft, an epicycloidal transmission was resorted to, the flywheel being made hollow. The pinion clamped on the shaft of the pump has in its turn such a diameter this it is located exactly between the speed reducer and the interior of the rim of the flywheel, consequently the entire apparatus for the reduction of the speed is placed inside the flywheel without increasing the space occupied by the aggregate.

Steam Engineering

Boiler Plant at the International Exposition of Printing and Graphic Arts at Leipzig in 1914 (*Die Dampfkesselanlage auf der Internationalen Austellung für Buchgewerbe und Graphik, Leipzig 1914*, A. Adler, *Zeits. des Bayerischen Revisions-Vereins*, vol. 18, no. 14, p. 135, July 31, 1914, 3 pp., 20 figs., *d.*). The article presents a description of the boiler plant of the power-house at the International Exhibition of Printing and Graphic Arts, Leipzig, in 1914. The triple flue tubular boiler had a heating area of 425 qm. (4574 sq. ft.), a gage pressure of 14 atmospheres and a superheater installed in the flues for a steam temperature of 350 deg. cent. (662 deg. fahr.). One of the conditions adopted by the technical board of the exhibiton was that the boiler should use exclusively lignite briquettes, which had to be taken into consideration in designing the grate. On top of the jacket of the upper header, there is a steam dome of 800 mm. (31.4 in.) in diameter and 800 mm. (31.4 in.) high. In it are placed the steam stop valves, a double safety valve and a reserve pipe. At the base of the dome is placed a manhole for the inspection of the interior of the boiler. In addition to this, on the upper header is located an attachment for a signalling apparatus and a water level regulator.

The steam superheater is of peculiar interest; it is arranged in such a manner that only part of the gases developed on the grate pass through it. The regulating valves are placed behind the superheater, which protects them from overheating. In addition to that, the arrangement of the superheater is such that the radiant heat stored up in the brick work in front of the superheater is utilized in the latter. The steam enters into rolled seamless superheater chambers which enclose the superheater tubes; it flows through the superheater in countercurrent to the entering heat gases and from the lower collecting chamber passes into the attached piping back to the triple valve, whence the superheated steam is led to where it is wanted. The employment of the triple valve permits, by a simple adjustment of the steam stop spindle, the use of saturated steam, superheated steam or a mixture of both. The adjustment of this valve can be made from the boiler room floor. Since the triple valves do not permit of seeing simply from the position of the hand wheel what kind of steam is used and which of the steam connections are open or closed, the German Association of Boiler Inspection Societies insists on a second stop valve being placed between the boiler and the triple valve. The rest of the article describes and illustrates the installation in detail.

Measurement of Water Temperature During Firing-Up of Tubular Boilers with Withdrawable Firetubes (*Messung der Wassertemperatur während des Anheizens von ausziehbaren Röhrenkesseln*, H. Winkelmann, *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 39, p. 443, September 25, 1914, 2 pp., *p.*). The article describes the methods of regulating the temperature of water during the firing-up of tubular boilers with withdrawable smoke tubes. In tubular boilers, leaks in the seams start quite often during the firing-up process, and even the lower rows of tubes seem to be affected in the same way. As a rule, this kind of leak appears the more frequently, the cooler the season, the colder the feed water and the more rapidly the firing-up process is carried on. It may be ascribed therefore to the considerable stresses created in the boiler sheets by the temperature difference between the various boiler parts and the water in the boiler during the firing-up period, and to the fact that with the usual boiler construction, there is not a sufficient circulation of water. It has been attempted many times therefore to apply special devices for speeding-up the

water circulation and equalizing as far as possible the heating of the water in the various parts of the boiler. This appears of the greater importance, in view of the fact that quite a large number of boiler accidents were recently ascribed to the incorrect heating of the lower parts of the boiler with withdrawal tubes. It has happened repeatedly that blow off tubes have been torn off and fire tubes have developed leaks through which boiler attendants have been either injured or placed in danger of injury.

The experiments described in this article have been made with a purpose of seeing to what amount the devices for producing rapid equalization in the heating up of the water are defective. Tests were made on three locomobiles of commercial types and various sizes, all with withdrawal tubes. In the first test, the heating up was made in a normal manner without the use of any heat equalizing device. In the second case, the heating up was carried at as rapid rate as possible with the help of an exceptionally experienced fireman, but no equalizing devices were used. Finally in the third test, both heat equalizing devices and exceptionally rapid firing up were used together or singly. The equalizing devices used were a special type of injector which sucked in water and delivered it through a 3-way pipe of which the three branches were in the lowest part of the boiler—one in front, another in the middle and the third in the rear of the boiler. The second equalizing device was a Howald temperature equalizer, which has a serpentine of special construction. Complete data of tests are given in a table in the article.

It appears that the heat equalization produced by means of the injector is superior to that produced by a serpentine, but the latter has the advantage of working automatically and does not have to be under constant supervision, contrary to the case when the injector is used. Both devices begin to act only after the steam begins to be generated and up to that instant, in both cases, the boiler remains subjected to the great stresses produced by temperature differences. The instructions generally given by the manufacturers of tubular boilers with withdrawable tubes, to the effect that during firing up a part of the boiler, water should be let out by the blow-off cocks, is at best only an emergency measure. The best method of protecting the boiler, which unfortunately, however, can be applied only in a limited number of cases, is when starting it up to fill it with water previously heated to 212 deg. fahr. It appears also that the device proposed by Altmayer for use on modern boilers and locomobiles may be applied for improving water circulation also in tubular boilers. Although it does not begin to operate right from the start of the firing-up process, it acts at an earlier period than the serpentine device. The author comes to the general conclusion that the manufacturers of tubular boilers ought to pay more attention to making their product safer in operation and more economical.

Large, Straight Flow Steam Engines in Metallurgical Plants (*Grosse Gleichstromdampfmaschinen für Hüttenwerke Schömberg. Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 35, p. 411, August 28, 1914, 2 pp., *p.*). The article discusses the application of large, straight flow steam engines in metallurgical plants. The great advantages of this type lie in its reliability, simple attendance, low steam consumption, limited floor space requirements, ability to carry large overloads and exact regulation, unlike, in the latter regard, compound engines. During the last few years they have been rapidly introduced for direct drive on rolling mills, in particular for three-high rolls where, notwithstanding a large variation in output, a constant speed of rotation is necessary. A compound engine with a large, low pressure cylinder and a complicated method of control, would satisfy this requirement only at the cost of a large expenditure in power, and even then no reliance could be placed on it. The flywheel, even though of very generous dimensions and run at the peripheral speed up to 35 m. (114.8 ft.) per second, would not fully equalize the varying load, and in addition to that, the overload capacity of a compound engine is quite limited.

Table I gives some data about the larger works where rolling mill drives by straight flow engines has been introduced. In the case of some of these engines, very high piston velocities appear to be used (up to 5.5 m. (18 ft.) per second) without any damage to the installation and without unfavorably affecting the operation of the machinery. Tandem engines of similar dimensions would not permit this being done. The initial cost of the engine is said to be on an average of from 20 to 30 per cent lower than that of the tandem engines of equal size and equipment. To this must be added the saving in cost of foundation—about 10 per cent. The cost of operation is said to be very low: the average consumption of steam, in the case of engines rated at about 1500 h.p., at 10 atmospheres pressure and 250 deg. cent. (482 deg. fahr.) temperature, vacuum of 88 to 90 per cent and 90 per cent mechanical efficiency of machinery, may be counted on at 5.8 to 6 kg. (12.8 to 13.2 lb.) of steam per effective h.p.h. in the case of normally working rolls, or including condensation and losses in the condenser, 6.5 kg. (14.3 lb.) at the shaft of the rolling mill. Since good tandem engines in continuous operation have shown a steam consumption of 8.9 kg., the saving in steam appears to be around 25 per cent. In addition to that must be considered the economy in lubricating materials due to the absence of one cylinder and its valve gear.

Of particular interest are the extra large engines marked as 9 and 10 in the table. No. 9 has been put in to take the place of a tandem engine, which used to drive a beam and rail rolling mill at a consumption of 10 kg. (22 lb.) of steam. Although the plant has at its disposal a cheap source of electrical energy, it has been decided to drive the rolls by steam and not by electric motor. The engine works with steam pressure of 7 to 8 atmospheres, which it is proposed to increase to 12 atmospheres. Extensive tests of steam consumption have after a considerable period of operation shown the consumption without condenser losses to be 5.3 kg. (11.6 lb.) per indicated h.p.h. at a load of about 3000 h.p., with 7 atmospheres pressure, 300 deg. cent. superheat and 9 per cent vacuum. The engine marked at No. 10 is used on a modern high efficiency rolling mill.

Experiences in Electric and Autogenous Welding of Steam Boilers (*Erfahrungen über elektrische und Autogenschweissungen an Dampfkesseln. Zeitsch. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 25, p. 303, June 19, 1914, 2 pp. *cp*). The article is a report of papers read at the 43rd meeting of delegates and engineers of the International Association of Boiler Inspection Societies by Münster and Eggers, on the subject of experiences in electric and autogenous welding of boilers. Experience has gener-

ally shown that autogenous and electric welding are approximately of equal value, although it may be stated that electric welding is somewhat preferable on account of more limited local heating of the material. Both processes are being introduced in the construction of boilers and so far have been used only in the case of small vertical boilers, mostly fire-tube type in which the fire tubes and partly the bottoms are welded in. It appears further that both kinds of welding are justified on parts subject only to compression stresses and only quite small and temporary tension stresses. The welds must be executed only by fully reliable concerns and no hammering on the welded seam, when blue heat has been applied, should be allowed. Mr. Eggers stated that in Germany electric welding on steam boilers, steam con-

TABLE 1 DATA OF LARGE STRAIGHT-FLOW ENGINES IN METALLURGICAL PLANTS

No.	Name of Plant	Kind of Mill	R.p.m.	H.P.	Dimensions
1	Burbach	small section rolling mill	90 to 130	700 to 1000	43 in. stroke
2	Ph. Weber, Hostenbach	sheet rolling mill	60 to 70	800 to 1000	rebuilt from tandem engine, 49 in. stroke
3	Rombach	structural iron rolling mill	90 to 120	1600 to 2200	41 in. bore, 51 stroke
4	Siegen Iron Works	middle roll	60 to 100	1900 to 1200	43 in. stroke
5	Dusseldorf Iron and Wire Co.	small section and wire mill	90 to 100	800 to 1150	43 in. stroke
6	Dusseldorf Iron and Wire Co.	wire mill	100 to 110	1500 to 1900	51 in. stroke
7	Hahn Works, Grossenbaum	universal rolling mill	85	1600 to 2200	rebuilt, 51 in. stroke
8	Konigin-Marienhütte, Saxony	small section rolling mill	80 to 100	1000 to 1300	47 in. stroke
9	Roehling Steel Works	beams and rails, 28 in. diameter	110	4000 to 6200	66.9 in. bore, 55 in stroke, 8 atmospheres
10	Westfalian Steel Works, Aplerbeck	wire mill	100	3000 to 4500	57 in. bore, 59 in. stroke, 12 atmospheres
11	Bros. Stumm, Neunkirchen	structural iron rolling mill	80 to 120	2400 to 3200	37.4 in. bore, 51 in. stroke, 9 to 10 atmospheres

tainers and general steam apparatus under stresses is comparatively little used as compared with welding by the acetylene-oxygen flame, but has been widely introduced in Russia and found its way to Western Europe from there. In repairs on steam boilers acetylene welding is still widely used, but many of the steam inspection societies in Germany are gradually coming to the use of electric welding.

Strength of Materials and Materials of Construction

Notch Action in Machine Parts and Boiler Sheets (*Die Kerbwirkung bei Maschinenteilen und Dampfkesselblechen, Zeits. des Bayerischen Revisions-Vereins*, vol. 18, nos. 15 and 16, pp. 150 and 157, August 15, and 31, 1914, 4 pp., 9 figs., *tp.*). The article discusses the influence of the presence of notches on the strength of machine parts and boiler sheets. In a paper On the Influence of Notches on the Strength of Machine Parts, presented some time ago by Professor Heyn, of the Royal Testing Laboratory in Grosslichterfelde, he expresses the fundamental law of the action of notches in the following way:

"Notches act as local powerful intensification of stresses."

Some time previously, Doctor of Engineering Preuss extended the same view to the case of the metal surrounding holes and notches in boiler plates and has shown in particular the obnoxious influence of hand punching or caulking. The harm done to boiler plates in the process of knocking off scale belongs to the same class, since indentations made on the plate by sharp instruments are nothing but notches and have all the harmful consequences of them as regards the distribution of stresses in the plate. Professor von Bach has repeatedly called attention to the fact that cracks in boiler sheets can be ascribed to indentations originally produced in knocking off boiler scale. Further, when the boiler sheets are cut, the action of the shears produces cracks which lead to injuries of the plate. It is always advisable, therefore, to remove the sharp edge of the cut plate. Professor R. Baumann has also called attention to the tendency of small cracks to extend through wrought iron, while Professor Heyn, in the above referred to paper, expresses the opinion that under certain circumstances, apparently quite negligible notches may materially reduce the ability of the plate to withstand repeated stresses. Even indentations as small as those produced by the marking tools as well as

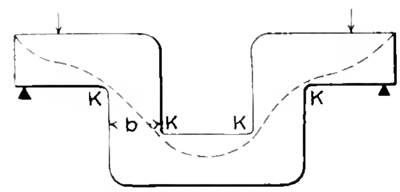


Fig. 4 Distribution of Stresses in a Crank

quite unnoticeable blow-holes may lead to the development of dangerous notching action.

The article goes into particulars as to the ruptures developed in machine parts due to the initial presence of notches, and shows that slots for cotter for fastening the piston rod to the cross-heads, often become the starting points for ruptures, owing to the notch action. The distribution of stresses along the edges of the slots is just as little favorable as that along the circular edges of a hole in a plate. Among other things, Professor Heyn refers to the extremely illuminating experience of Hoenigsberger, who found that in the case of a crank, the neutral fibre, free of stresses, runs somewhat like a curve (Fig. 4) passing very close to the inner angles K on all sides. Professor Heyn states in this connection that the maximum stress will be found at the edges K, and it was actually found that the neutral fibre passes close to these edges. Therefore, the edges of the notches in these parts enter to a certain extent into the neutral fibre and the result is that the stresses producing equalization of the moment of torsion are applied with a short lever arm; they are materially larger than those which are connected with the long lever arm at a considerable distance from these angles and experience has actually shown that these angles represent the most endangered part of the crank, and that in the majority of cases rupture occurs in exactly that location.

The above considerations lead the author to emphasize the necessity of the notch shock test for the determination of

strength of materials and proper construction of notching parts.

Alteration of Shape Taking Place in Upsetting of Metal Cylinders (*Der Umformungsvorgang beim Stauchen von Metallzylindern*, L. Weiss, *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 36, p. 1376, September 8, 1914, 2 pp., 6 figs., *e.t.*). The present article contains illustrations and some new data concerning the processes taking place during the upsetting of cylindrical metal bodies. If a copper cylinder is upset under a hammer, there takes place a certain reduction of the height of the cylinder, and there appears at the terminal surfaces of the cylinder a circular area concentric to the edges. During further upsetting, the ring surface between the core circular surfaces and the edge gradually increases. In the case of copper this phenomenon does not appear in a clear manner, but with copper-manganese alloy containing approximately 6 per cent manganese, the internal circular surface comes out with such a sharp difference from the ring surface at the edge that the first impression is that the two are of different metals. In Fig. 5A, the external diameter D and the diameter of the core surface D_0, as they vary with the decrease of height of the cylinder, are shown by respective lines for a copper cylinder, 27 mm. (1.06 in.) in diameter and 54 mm. high (2.12 in.). In Fig. B are shown similar results obtained in the case of a copper-manganese cylinder 24.5 mm. (0.96 in.) in diameter and 49 mm. (1.92 in.) high.

To explain this striking phenomenon, a metallographic test was made. The polishing of the two terminal surfaces and their microscopic investigation has not given any appreciable results. The author found, however, that the displacement of the crystals in the metal was noticeable if a longitudinal cut of the metal was taken since it was found, as shown in Fig. C, for example, that the lines of flow of metal were generally parallel to the longitudinal axis of the cylinder, but that they made a sharp break at the edges and continue to run horizontally. The line of demarkation of the core surface occurs at the point of change of direction or just where the line of flow passes into the horizontal. In Fig. C these points are shown at the lower edge, in little circles; at the upper edge of the cylinder the little white lines indicate the original diameter of the cylinder.

ENGINEERING SOCIETIES

AMERICAN INSTITUTE OF MINING ENGINEERS

Bulletin, no. 94, October 1914, New York City

The Safety Movement in the Lake Superior Iron Region, E. Higgins

An Aerial Tramway for Mining Cliff Coal, A. E. Gibson

A New Safety Detonating Fuse, H. Souder

Gasoline Locomotives in Relation to the Health of Miners, O. P. Hood

A Test of Centrifugal Motor Driven Pumps, S. S. Rumsey and W. F. Schwedes (abstracted)

A Test of Centrifugal Motor-Driven Pumps, S. S. Rumsey and W. F. Schwedes (22 pp., 11 figs., *e.*). The paper presents data of a test of centrifugal motor driven pumps made at the Chapin Mine of the Oliver Iron Mining Co., where pumps are driven with electricity generated by water power. The article describes the general arrangement of the pumps, piping and electric control. The pumps were two 3-stage pumps working at an estimated dynamic head of 112 ft. against which they will have to operate when drawing 3000 gal. of water per minute, and two 6-stage pumps operating at the same capacity against an estimated dynamic head of 1000 ft. The pumps are of the multi-stage turbine type built in units of 3 stages each. The two single pumps each consist of one unit of 3-stages mounted on a common cast iron bed plate with a 450 h.p. 1200 r.p.m. induction motor direct connected through a flexible coupling. The double pumps each consist of two 3-stage units driven by a similar induction motor of 1050 h.p. The motors are 3-phase, 60 cycle 2200 volt wound-secondary induction motors.

The article describes the method of taking the tests which does not materially differ from the usual practice, and gives complete data of the tests in the form of tables and curves. The purpose of the test was to determine for each pump with its motor, the head-capacity curves of pumps; over-all efficiency, wire to water, degree with which builders' guarantees were met, and the mechanical operation of the pumps and motors for vibration, thrust, heating and noise. As regards the wire to water efficiency at 3000 gal., the maximum

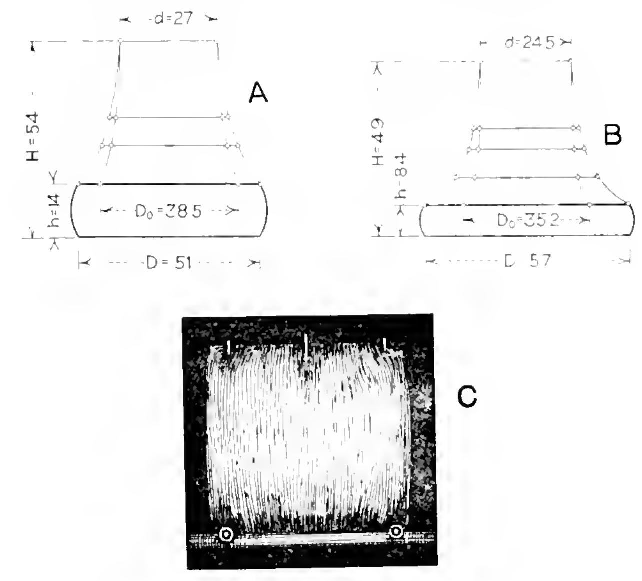


Fig. 5 Upsetting of a Metal Cylinder

obtained was 75 per cent. The pump bearings and oil for thrusts were water cooled, but no water was passed through the coils during the tests. The pumps ran very quietly on all loads and the 3-stage pumps with little vibration. In the 6-stage pumps some vibration occurred on account of the difficulty in holding the alignment of the long cast iron pieces on the steel flue plates. Absolute alignment of these pumps is of prime importance and their successful operation will depend more upon this than any other one factor.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Proceedings, vol. 30, no. 5, June 1914. Pittsburg.

Discussion on Measurement of the Velocity of Flowing Water (by Lewis F. Moody) and Pitot Tube Formulas —Facts and Fallacies (by Benjamin Feland Groat)

Air in Jet Condensers, C. L. W. Trinks

Discussion on Measurement of the Velocity of Flowing Water (by Lewis F. Moody) and Pitot Tube Formulas—Facts and Fallacies (by Benjamin Feland Groat) (90 pp., 22 fis., *apt.*). For abstract of the original article, see *The Journal*, October, 1914, p. 201. Prof. Gardner S. Williams told about his experi-

ments with the Pitot tube. He had occasion to rate the same instruments in still water by dragging one attached to a car and also to test them in running water where the water passing the instrument was determined by measurement, and he has never been able to get the two ratings to agree. His opinion, therefore, is that in still water, the stationary Pitot tube does not get a rating that it would get by running past a measured quantity of water. Neither does he believe in the precision of current meter measurements. He had occasion to have a Haskell meter rating made in turbulent water. A quantity of water passing down the experimental canal at Cornell University was measured over a weir and then measured by a current meter in the hands of Professors Schoder and Turner, of the instructing staff of the University. Professor Turner had been in the employ of the United States Lake Survey and had participated in the stream gaging work on the St. Mary's River, according to the practice of the United States Lake Survey, which represents about the highest type of current meter work that has ever been produced. He testified under oath that the methods at Cornell were in entire harmony with those of the United States Lake Survey, and were of equal accuracy as far as manipulations were concerned. Nine gagings were made and the results showed that in the turbulent water which existed in the canal, although no more turbulent than is encountered frequently at gaging stations in a stream, the Haskell meter under-registered in the extreme case something over 9 per cent and in all cases over 3 per cent.

Bernoulli's theorem claims that the sum of the three heads must be constant in any stream line if friction be neglected. In experiments made by the author at Cornell University, he found that the pressure at the center of the pipe is less than at its wall. He took an instrument consisting of a flat plate having an orifice connected with a small tube and starting at the wall, he moved this plate across the stream, keeping it always parallel to the axis of the pipe. He found that at the wall, the pressures transmitted to the orifices coincided almost exactly with those indicated on the perforations in the periphery of the pipe in the same plane. As the orifices passed out to the center, the pressure appeared appreciably less.

Edward S. Cole told of his experiments made in the nineties and later, with the object of producing a practicable instrument for use in gaging the flow of water in the street mains of Terre Haute. It was found that there was a decided advantage in the use of the duplicate orifice, one bent upstream and the other downstream. A photo-recorder has been developed which has made the instrument more complete and efficient. The combined apparatus was given the name of Pitometer.

N. C. Grover of the United States Geological Survey discussed the general subject of measuring the velocities of water as actually done in the work of the Geological Survey. The stream gaging work of the Geological Survey has been conducted with a much higher degree of accuracy than would be warranted by the probable use of the resulting data. The work of the surveying engineer is very diversified and often done under difficult conditions, but is almost always required to give dependable results. The instrumental equipment for such work therefore must be simple, light and universally adaptable. The Fteley meter is perhaps the most accurate of current meters within the limits of its particular use. The Haskell meter is recognized as one of the best for work on large rivers. The Price meter is not very accurate when used in turbulent water, but under conditions that cause a vertical motion of the meter, or when used under proper conditions, it will give results within reasonable limits of accuracy. The Survey, several years ago, employed an expert mechanician in an unsuccessful attempt to convert the screw type of current meter into a form for universal use, but later had to abandon it owing to the lack of available funds.

William Kent stated that he has used a Pitot tube as a check upon other methods of measuring the discharge of a pump at high pressure, and found its readings to give measurements which agree within one per cent of those obtained by a calibrated nozzle and pressure gage and those obtained by a weir, using the Francis formula.

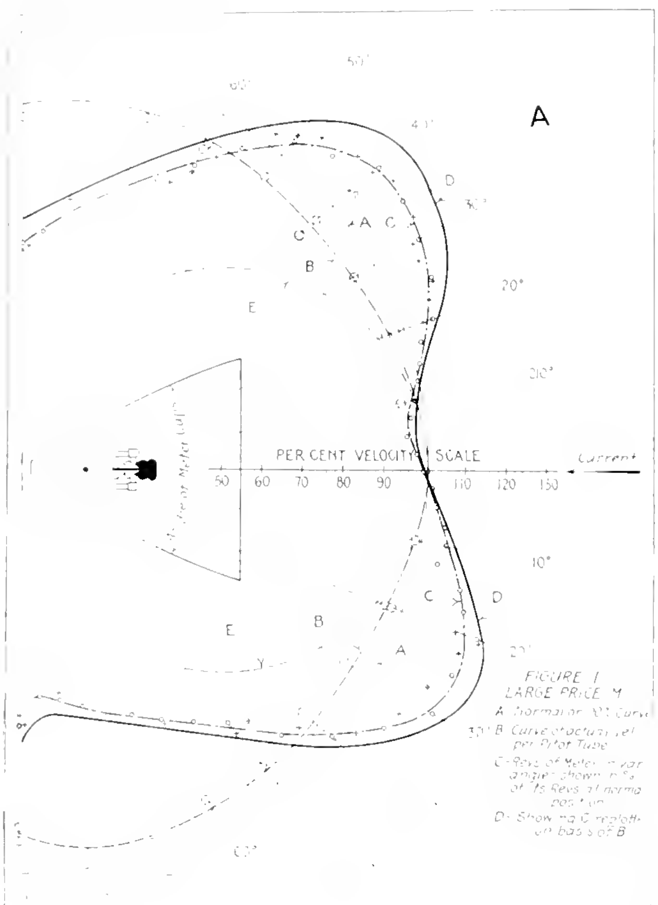
Professor Charles M. Allen stated that he had made several hundred experiments with Pitot tubes of various types to determine the coefficients of the instruments for still water and moving water ratings. It was found that the ratings were constant, but in all cases the coefficients varied with the velocity. In still water in every case, they were higher than in moving water readings to the extent of from 3 to 5 per cent. Pitot tubes should be rated in moving water at the same velocities at which they are to be used.

Morris Knowles related some of the early history of the velocity-of-water measurements. In experiments conducted upon jets issuing from standard orifices, it was very evident that a marked retardation of velocity in the jet occurred about the outer edge. If Bernoulli's theorem were applied to two points, one at the center of the jet and the other at the outer edge in the same plane, the decrease of the velocity head at the outer edge would necessitate an increase in the pressure head to balance the greater velocity head at the center, but if the outer edge of the jet were under greater pressure than the center, this pressure would cause the jet to lose its form, which appears to show that the Bernoulli theorem is not applicable to two such points.

A. H. Brown and F. Nagler have given a preliminary report of experimental work performed with a view of determining the possible causes of the over-registering of the cup type of current meter. It fully describes the method of tests and shows the arrangement of apparatus for testing current meters. It was found that if the meter be placed at a slight angle either above or below a horizontal, that the revolutions increased very materially. At 90 deg. positions above or below horizontal, it showed contrary to expectations, approximately one-half the number of revolutions that it registered in its normal presentation to the flow and in the same direction. The curve shown in Fig. 6 indicates also the shifting of the whole curve occasioned by the difficulty experienced in fixing the normal position. Under constant velocity of water, this particular meter will over-register as high as 25 per cent when placed at an angle to the normal direction of flow vertically. This effect, however, is slight up to the 45 deg. limit and is merely to reduce the number of revolutions, the reduction increasing with the angle.

On the curve of Fig. A, the circle *A* is drawn to show the theoretical performance of the cup type of meter when placed at various horizontal angles. Under such conditions, neglecting the effect of the frame, it may be assumed that a constant velocity will be registered regardless of the angularity of the meter. This circle also shows the performance of any type of meter so supported that it is free to

swung ... direction ... from the ... normal ... on one-half the diameter ... the length of the various vectors therefore ... the components of velocity and represents ... performance. The dotted curve C is plotted ... test readings of the meter under test and indicates ... 25 and 35 deg. ... the approximate maximum error. These lines lie at an average angle of 30 deg. with the horizontal, which corresponds to the 60 deg. angle approximate ... of the bucket itself. This double curve C is plotted ... the basis of percentage of curve A. The error would be greatly emphasized if it were plotted in on



giving resultant components of velocity when subjected to flow that was distributed uniformly in all directions, but preponderance of angularity in any one direction, either horizontally or vertically, caused over-registering or under-registering. In turbine work where the measuring section is selected upstream from the turbine adjacent to the entrance of the channel, the meter is apt to over-register.

The general conclusions of the speakers are that even the best cup type of meter should preferably be used swinging and never rigidly supported unless it is known that disturbances are uniformly distributed in all directions, a thing which can hardly be accomplished in practical work. The ideal meter is one which being rigidly supported in disturbed water, will register only two components of velocity when subject to flow from any direction. This means that it must have identical, vertical and horizontal characteristic curves and to do this, the axis of rotation must coincide with the normal direction of flow which at once limits the choice to the screw type of meter, the design of the head of which shall be such as to give the desired true components.

Herman Bacharach told of his experiments in recording

B

AIR VELOCITY IN METER -SEC.	SHORT TUBE	MEDIUM TUBE	POINTED TUBE	LONG TUBE WITH FUNNEL	TUBE WITH DISC
	In Millimeter - Water Gauge				
2.29	0.342	0.342	0.342	0.342	0.342
2.76	0.460	0.490	0.504	0.494	0.507
3.23	0.660	0.690	0.714	0.680	0.686
3.68	0.860	0.910	0.920	0.910	0.890
4.13	1.070	1.130	1.150	1.120	1.123
4.57	1.290	1.350	1.370	1.370	1.379
4.94	1.530	1.570	1.600	1.590	1.615
5.27	1.740	1.810	1.810	1.810	1.838
5.65	1.980	2.050	2.060	2.080	2.118
6.20	2.350	2.450	2.410	2.420	2.540
6.64	2.650	2.770	2.770	2.770	2.780
6.97	3.000	3.150	3.150	3.150	3.210

Fig. 6 Measurement of Flow of Water by Current Meters and Pitot Tube

the basis of circle B, which shows the true resolved components desired.

The Pitot tube readings are shown along curve B, which is also plotted in percentage of A. The curve D is replotted in percentage of A by basing C on B rather than on A.

Contrary to general ideas of the performance of the cup type of meter, it appears that in this case the over-registering is due to the fact of angularity of flow in a vertical plane rather than to that in a horizontal plane. The angularity of flow in a vertical direction speeds up the meter to a considerable amount over the known error due to horizontal angularity of the flow. It appears, therefore, that the large Price meter should only be used when it is swinging free in all directions. The next series of tests were made with a small Price single point cup type of meter as made by Gurley. The data of these tests are given in a curve similar to the above. When rigidly supported, the modern small Price cup type of meter was found to be remarkably accurate in

the velocity of flow with a Pitot tube. He gives a table of velocities (Fig. B), showing the results of tests made with various shaped tubes where little variation has been evident with the different types of tubes, the greatest difference being shown by the short tube. He also describes an instrument for indicating or recording dynamic pressures. Mr. W. M. White discusses the diversity of opinions with regard to the correct formula for h in the pitot tube measurements. He has devised a special apparatus for determining, experimentally, the true relation between the head and velocity. He found that the formula $h = \frac{v^2}{2g}$ is correct for the point of the Pitot tube, and then devised a rather simple apparatus for obtaining the true pressure in the water at or near the point of the Pitot tube in order to find the increase of pressure in the impact pipe caused by the velocity striking the Pitot tube point over the static pressure in the pipe. Here again he found the same formula to hold good. In order to

test the statement of Gardner S. Williams, that the pressure in the water measured along the diameter of the pipe is not the same, but varies in accordance with Bernoulli's law, he designed a special apparatus in which provision was made to discharge a jet of water at various velocities as high as 30 ft. per second, through a $3\frac{3}{4}$ in. disc nozzle. The object of the experiment was to determine the pressure within the jet of water at high velocity and more particularly to establish the fact as to whether the velocity along the shortened rod, as a piezometer holds, affected the pressure reading at that point. While some of the curves obtained would seem to indicate a slight difference in pressure between the center of the jet and its outer edges, the author comes to the conclusion that it may be expected with reasonable certainty that the velocity is the same across the jet. From other curves, it was found that the pressure in the water dropped to atmospheric just at the edge of the nozzle. The only explanation that the author can give for it is that it is due to surface tension on the jet. It appears, therefore, that there is no drop in pressure due to high velocities.

The closure of Prof. Lewis F. Moody, while of great interest, is too extensive for abstracting.

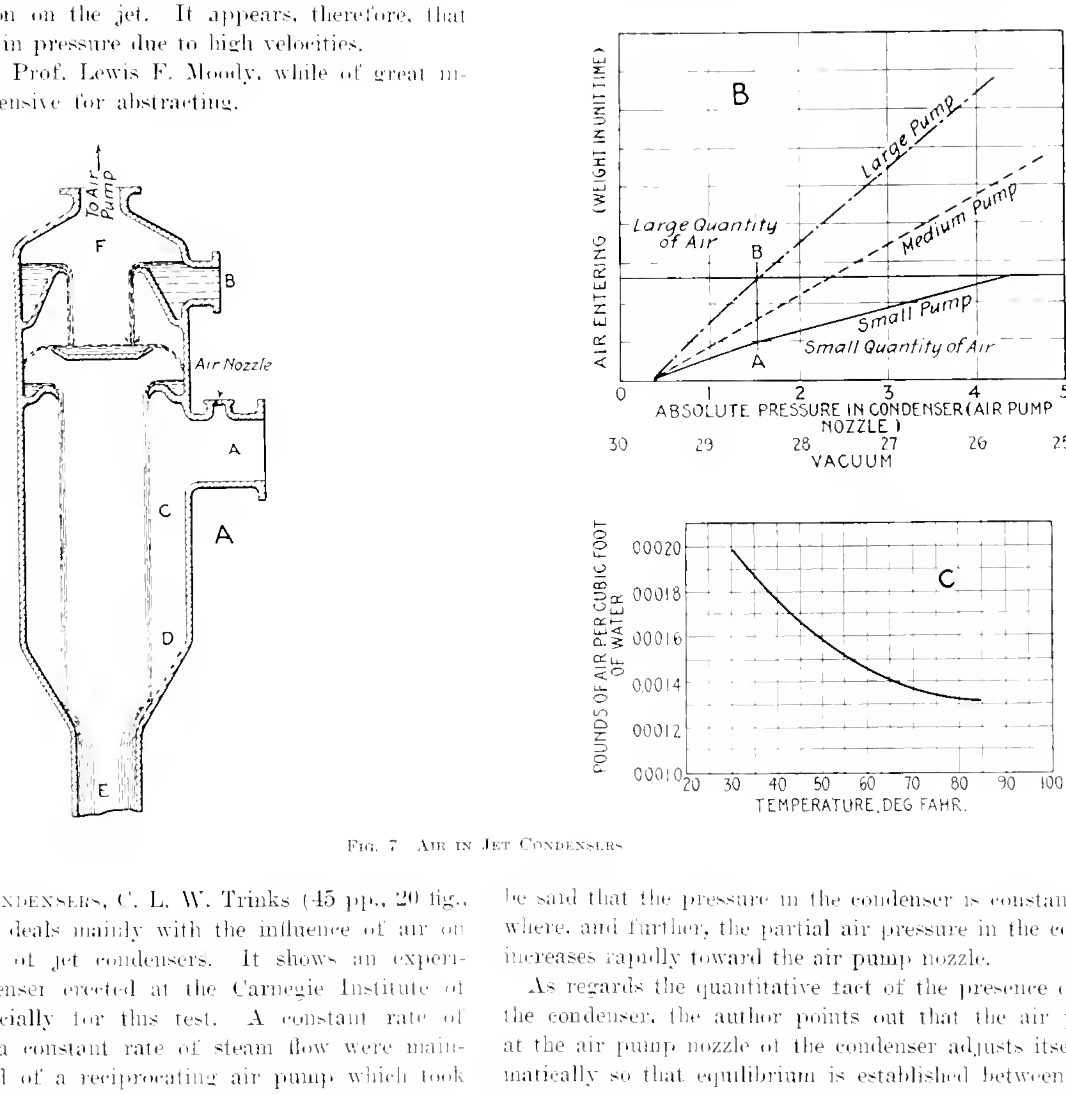


Fig. 7 Air in Jet Condensers

Air in Jet Condensers, C. L. W. Trinks (45 pp., 20 fig., *et*). The article deals mainly with the influence of air on the performance of jet condensers. It shows an experimental jet condenser erected at the Carnegie Institute of Technology especially for this test. A constant rate of water flow and a constant rate of steam flow were maintained; the speed of a reciprocating air pump which took air out of the cool top of the condenser was also maintained constant, but a variable quantity of air was admitted with the steam through orifices. Although the weight of air admitted through the largest nozzle did not exceed 1.4 per cent of the weight of steam entering at the same time, the vacuum dropped from 28.5 to 23.2 inches, which means the difference between very good and very poor vacuum. The temperature distribution in the condenser as shown by the diagram of Fig. 7, explains how even a very small quantity of air spoils the vacuum. The temperatures were measured at points A, B, C, D, E and F. If the condensation were most efficient, the temperatures at A and E would be the same, as was found to be the case in a test with no air in the steam. As more and more air was admitted however, the temperature at E (tail pipe) did not change, but that at D, C and A changed, rising slightly at D, more at C and the most at A. The temperature at E remained constant because, although the steam admitted was apparently hotter, it really, in spite of its higher temperature, contained no more heat because it contained more water. In a condenser which takes steam from an engine or turbine, however, the tail water temperature would rise with the addition of air to the steam on account of the increase of steam consumption for a given load on the prime mover caused by the dropping of the vacuum. Neglecting the normal slight pressure drop between the steam entrance A and the air pump nozzle, it may be said that the pressure in the condenser is constant everywhere, and further, the partial air pressure in the condenser increases rapidly toward the air pump nozzle.

As regards the quantitative fact of the presence of air in the condenser, the author points out that the air pressure at the air pump nozzle of the condenser adjusts itself automatically so that equilibrium is established between the air entering and the air removed, the latter being accomplished not only by the air pump, but also by the tail water. The capacity of an air pump in pounds of air in unit time is expressed by its characteristic or characteristics which can be found only by actual tests. If, however, the builders of air pumps know these characteristics, they do not publish them which makes the performance of condensers entirely uncertain, as the condenser owner has no means of knowing

how much air leaks in or how much he pumps out. Further, all the characteristics of air pumps which have been published are based on the pumping of dry air which may be entirely different from the characteristics of air and vapor mixtures.

Fig. B shows the influence of air pump characteristics on vacuum. It assumes the knowledge of the characteristics of the air pump on a given condenser as well as the knowledge of the temperature at the air pump nozzle and absence of appreciable pressure drop between the air pump and the air pump nozzle in the condenser. The characteristics of three similar pumps of different sizes are indicated as well as two rates of inflow of air. It is evident that the same vacuum may be maintained in spite of different rates of air inflow if corresponding air pump capacities are employed. In connection with the use of the characteristics for actual condensers there are two difficulties; in parallel flow condensers, the lack of definite knowledge of the temperature at the air pump nozzle, and in countercurrent condensers, the possibility of pressure at the air pump nozzle of the condenser being different from the pressure in the condensing space proper. The author comes to the conclusion that the temperature of the air and vapor mixture depends upon the rate of air inflow and air removal while the rate of air removal depends upon the temperature of the air and vapor mixture. He discusses the influence of air pump capacity in countercurrent condensers at considerable length.

As regards the weight of air in a condenser under normal conditions, the injection water carries up to 2 per cent of atmospheric air by volume or approximately $^1/_{400}$ per cent by weight, or, further, $^1/_8$ per cent of the weight of the steam; some of this air stays in the water even at the low pressure of the condenser. The weight of air coming in with the steam from the boiler feed water is usually negligible, but air enters the condenser with the steam on account of leaks. This depends on the average air pump capacity which may range from 2 to 4 times the quantity of air entering with the water. If more enters, the vacuum must drop. Tests of condensers show reasonable uniformity in the effects of air leaks. The author gives a curve derived from a test on a Mesta barometric condenser and a Westinghouse Le Blanc condenser. With 1 per cent of air by weight in the exhaust steam, the vacuum is exceedingly poor. The author states, however, that there is no reason why that should be so, provided the air pump is made large enough and there is a sufficiently free passage in the condenser for the air. The point is only where to draw the line and whether to build a condenser and pump for an $^1/_8$ per cent leakage or for 1 per cent or more.

This question leads to a good deal of quarreling between the condenser builders and the condenser owners, and could be easily avoided by devising an instrument for the correct measuring of the quantity of air in exhaust steam. The author briefly describes the principle upon which he worked in order to devise an air detector. The device is said to be really a reliable piece of laboratory apparatus but a very poor instrument for power plant use.

He proceeds to discuss the influence of subdivision of injection water. Observation through the glass windows of the experimental condenser at the Carnegie Institute of Technology revealed the fact that the steam blew the sheets and jets of water literally to atoms, producing a vast condensing surface in a small space. The following fact proves further that the condensation was completed in a very small space; the tail water level was gradually raised in the condenser until it touched the steam pipe and no change in the vacuum could be noticed, although the steam flow and water flow were quite heavy compared with the size of the vessel.

In the discussion which followed, Karl Nibecker stated that he recently conducted tests on a condenser where the drop in the vacuum from the air pump to the steam inlet nozzle was 0.66 in. of mercury. He believes that this excessive drop was due entirely to poorly designed weirs and insufficient condensing area at the base of the vessel. In a condenser with the weirs properly designed, the drop in vacuum has been found to be less than $^1/_2$ in. He suggested further that it would be good practice to make the air pump capacity 8 to 10 times the amount of air brought in by the water and usually operate the pump at very slow speeds. When air leaks are developed during the operation, the pump speed can be increased and a reasonable vacuum maintained until such time as the pump can be taken off conveniently for repairs. He also described a type of air detector which is expected to give good satisfaction.

W. E. Snyder stated that after a wide condenser experience, he finds that the only feature which gives the most trouble to condenser men is the lack of air pump capacity due to insufficient attention to operating conditions by the companies designing condensers. Another difficulty in connection with the operation of condensers which is being gradually eliminated, however, is driving both the air and water pumps by means of one prime mover, making it impossible to vary one independent of the other. While the speaker agreed with the general statement that some leakage of air into the exhaust system under vacuum is bound to occur, he suggested several general rules for keeping this leakage down to minimum.

J. B. Shatzer describes a multi-jet condenser based on the principle of subdividing the condensing water and passing it through the condenser at a high velocity. No complete tests on this type of condenser have yet been made, the only point on which data have been obtained being the water ratio of the condenser and the amount of air handled without admitting steam. The water ratios run on an average higher than is required for the ordinary jet condenser. In most cases, the difference in the temperature between the theoretical vacuum and the tail water is about 15 deg. or higher than that obtained by other condensers. This is not considered disadvantageous by the builders, because the work ordinarily done by an air pump in a condenser system is in this case taken care of by the extra water passing through the condenser, this being resorted to in the belief that it is more economical to remove air by means of a highly efficient water pump than by an air pump of low efficiency. A set of curves is given to show the air handling capacity of a jet condenser, showing its increase with the pressure maintained on the condensing water, and also showing that with the pressure of 15 lb. in the water head, it is possible to admit 0.7 lb. of air per minute and still maintain a vacuum of about 20 in.

R. M. Rush told of his experiments with carbon packing and steam sealed glands on turbines and engines. They had to deal with an exhaust steam turbine operating in connection with an engine and governed entirely by the engine. It was found that at partial load the vacuum would go back into the engine cylinder. Under these conditions, the air

leaks around the stuffing boxes of the engine would be so great that the vacuum would be interfered with in the condenser, but it would be possible to prevent the leakage of air along the engine piston rod by means of carbon packing rings split in three parts and held together with a spring. The author believes that low vacuum which is so common around steel mills might be bettered by the introduction of carbon steam-sealed packing on reciprocating units.

N. Owitz objected to having an air pump on a condenser larger than is really needed for the duty required on account of the additional expense. He described the principles of condensation in a jet condenser as well as the countercurrent type of such condenser, and gave the results of tests of the countercurrent jet condenser shown in a figure in the text. In that specific jet condenser, the cooling water can be discharged at exactly the temperature of the exhaust steam or at an efficiency of 100 per cent. With increased consumption of the cooling water in an ordinary jet condenser, a larger air pump and an increased power consumption by that pump would follow from an increased amount of air brought into the condenser by the cooling water. The countercurrent type of construction of a jet condenser and the consequent cooling of non-condensable gases passing through the air pump at a low temperature result in a minimum load on the air pump required to maintain a given vacuum in the condenser. The speaker pointed out that air can be introduced with circulating water in a suspended or globular state where the water supplied to the condenser has been allowed to become intimately mixed with the atmosphere.

In the case of still water, the amount of air in each cubic foot of water may be said to vary about as shown in Fig. C. While, however, the amount of air by weight dissolved in each cubic foot of water seems to be very small, the actual volume of air becomes very large because of the low pressure exhaust. Professor Trinks, in connection with the latter remarks, called attention to the fact that in a countercurrent type of condenser the pressures at the top and at the bottom are determined by different considerations. With a large, fast running air pump, small water flow and little air leakage, steam must break into the top of the condenser and spoil the efficiency of the air pump.

FRANKLIN INSTITUTE

Journal, vol. 178, no. 3, September 1914, Philadelphia, Pa.
Stability of Aeroplanes, Orville Wright (abstracted)
The Screw Propeller, W. F. Durand

Stability of Aeroplanes, Orville Wright (10 pp., *g.*). The article is an address made by Mr. Orville Wright when he received the Institute's Elliott Cresson medal. It presents a general discussion on the question of stability of aeroplanes and describes the development of the stabilizing and the conditions of loss of equilibrium. He concludes by describing the various methods of automatic stabilization.

IRON AND STEEL INSTITUTE

Advance copy, autumn section 1914.

The Decarburization of Steels in the Salt Baths Used for Heating Prior to Hardening, A. M. Portevin (abstracted)
Utilization of Heat Contained in Slag, W. L. Johnson (abstracted)

The Decarburization of Steels in the Salt Baths Used for Heating Prior to Hardening, A. M. Portevin. The article discusses the decarburization of steel when treated in baths of molten alkaline salts. Such baths are becoming more and more usual for the heating of steel bars prior to hardening. They allow much more rapid heating of the small parts and of gradually adjusting the temperatures of heating in addition to eliminating or at least considerably reducing the superficial oxidation. They involve, however, a little realized danger of producing spot or superficial decarburization, especially where the heating is prolonged. The author has carried out a series of experiments with the object of investigating this decarburization. He maintained for various periods in molten potassium chloride at a temperature of 1000 deg. cent., samples of a hypereutectic steel containing 1.46 per cent of carbon. It was found that with an increase in the length of time the samples remained in the bath, there was an increased decarburization marked both by the increase in the depth of decarburized layer and by the lowering in carbon percentage of the surfaces, falling as low as 0.2 per cent. The decarburization is most effective after quenching and is better revealed by the Shore scleroscope than by the Brinell test because the former applies only to a small depth. At 900 deg. cent. the decarburization is not so deep, but almost as great so far as the superficial lowering of the carbon percentage is concerned.

Experiments with the same steel in the salt bath described by Brayshaw for use in hardening furnaces (Potassium chloride 0.56; sodium chloride 0.39; soda 0.5; potassium ferro-cyanide 0.2) showed that the degree of decarburization is nearly the same as when pure sodium chloride was used and the influence of the small amounts of ferro-cyanide added with the object of counteracting the decarburization, did not appear very efficacious. The employment of mixtures of cyanide and cyanate of potassium has enabled the author to establish equilibria of carburization between steels and the bath so as to obtain simultaneously in the same bath the decarburization of hard steels and the carburization of dead-soft steels. The two phenomena appear then to tend toward a common limit which would be the carbon concentration of the steel which remains in equilibrium at 900 deg. cent. in the chloro-cyanide bath. This limit appears to be independent of the quantity of potassium cyanide present in the bath. It has been noted that very frequently when this bath contains cyanide of potassium and likewise when it contains ferro-cyanide of potassium, there appears subjacent to the carburization layers, needles of appearance similar to those described by Braune in his researches on the influence of nitrogen on iron and steel. The article contains tables of data obtained by these tests.

Utilization of Heat Contained in Slags, Walter L. Johnson. The article contains a description of the method for the utilization of heat contained in slags. It describes the apparatus used for producing the steam and the calandria, in this case the Kestner single-effect climbing film evaporator. At first it was intended to use the steam produced in an exhaust steam turbine, and after numerous experiments on blades of different metal, it was found that duralumin was affected very slightly so that a 50 kw. turbine with blades of this material was experimented with. The steam produced from ordinary gray Cleveland (England) slag contains about 0.5 per cent by volume of non-condensable gases: sulphureted hydrogen and nitrogen. They were absorbed by washing the gases with milk of lime to

absorb the sulphuretted hydrogen and then passing the remainder through a tube containing calcined Cleveland ironstone heated to a temperature of about 750 deg. cent., the nitrogen being taken care of by the air pump.

When at the end of two months the turbine was opened up, the openings were found to be partly blocked up with fine sulphur which had caused some wear of the blades. After this the direct method was abandoned and a water heater or heat exchanger introduced between the turbine and the primary generator. With steam from slag at 100 deg. cent. and the temperature in the calandria 91 deg., the mean of 22 experiments gave 173 gal. of water evaporated per hour and the average steam per hour condensed in the calandria was 190.2 gal. Experiments were also made to determine the amount of available steam from the slag by condensing and measuring it. The mean of 7 experiments gave 1017 lb. per ton of slag, but after deduction, 855 lb. of clean steam available for the turbine. Since the modern exhaust steam turbine with full load on and a vacuum of $28\frac{1}{2}$ in. can be guaranteed under the above conditions to use not more than about 27 lb. per h.p., this gives 31.6 h.p. per hour per ton of slag per hour.

As regards the cost, the author states that the difference in practice at different works makes it impossible to give the cost of running such a plant. Apart from handling the slag, the cost of the electric installation is the same as in the ordinary exhaust steam turbine plant of a similar size, and the attendant can regulate the water in the calandria. But there is about 2 per cent more power required for the greater amount of condensing water per h.p., and where the slag is already being granulated, there is the extra up-keep of the second elevator. One man per furnace should be able to attend to the primary generator and running in the slag, the remainder being mechanical.

SOCIETY OF CHEMICAL INDUSTRY (BRITISH)

Power Costs in Various Works. T. Rolland Wollaston. The present abstract is taken from the *Iron and Coal Trades Review*, as the library of the Engineering Societies has not yet received the proceedings of the Manchester section of the Society of Chemical Industry. It is devoted to a comparison between various methods of steam generation for power purposes with other thermal prime movers. The author does not believe that the ordinary boiler furnace provides a satisfactory means of burning coal to advantage. The same chemical reactions are supposed to take place where the coal is burned in a bed 9 in. deep on a boiler grate or 6 ft. deep in a gas producer. With the gas producer, however, the gas is generated and burned under conditions closely approximating theoretical accuracy. In the boiler furnace, on the other hand, even in the best practice, a very large amount of excess air is used which vitiates the results, while the maintenance of the correct conditions for combustion in a thin bed over an area of say 20 sq. ft. is a matter of impossibility, even with the most perfect mechanical stoking devices. At the same time, in the boiler furnaces the radiant heat of combustion is usefully employed, but dissipated in the producer.

The producer type of furnace attachable to boilers of the Lancashire and other types in which the air for combustion is highly preheated through the agency of the radiant heat of combustion, is said to have been experimented with with some success. Hitherto, the firing of boilers by producer gas has only proved a paying proposition when the by-products could be extracted from the gas previous to its combustion, and even then only on a large scale. It may be expected, however, that recovery gas producers in conjunction with special boilers will enable the plant as a whole to work at approximately the same efficiency as the normal hand-fired boiler, the resultant by-product paying for a large part of the fuel costs, and in certain cases even showing a profit.

The author proceeds to give data of cost of operation of various types of prime movers, such as steam turbines, the same plant with high duty gas fired boilers, a 2000 h.p. recovery gas plant with gas engines, 2000 h.p. of Diesel engines and a similar amount of power from peat gas recovery plant of the Mond system. The most surprising result is in the last one, for which the data given by the author are reproduced. Not only is the power free of cost, but there is an actual profit of 21 per cent on the capital outlay. The capital cost of the plant, however, is extremely high—higher than in any other type of prime mover:

TABLE 1 PEAT GAS RECOVERY PLANT, MOND SYSTEM WITH 2,000 H.P. OF GAS ENGINES

Capital Costs		
2,000 h.p. peat recovery plant ...		£24,000
2,000 h.p. of gas engines at £6......		12,000
Foundation and buildings and auxiliaries.		6,000
		£42,000
Running Cost		
Dr. to 33,000 tons of peat at 5s		£8,250
" 2,140 tons of acid at 33s		3,530
" Oil and stores, say......		700
" Bags and packing sulphate		713
" Labour, 27 men at £70.		1,890
" Maintenance at 2 per cent.		840
" Interest and depreciation, 10 per cent		4,200
		£20,123
Cr. by 2,140 tons of sulphate at £12 10s	£26,750	
" 2,140 tons of tar at 20s	2,140	
		28,890
Credit balance.		£8,767
Cost per h.p. hour.		nil.
Cost per h.p. year		nil.
Equivalent cost per unit		nil.
With a clear profit of 21 per cent on capital outlay.		

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

PERSONAL NOTES

Charles L. Samson, formerly associated with The Griffin Wheel Company, Chicago, Ill., as mechanical engineer, has accepted the position of master mechanic of The Hamilton Manufacturing Company, Two Rivers, Wis.

Thomas L. Tomlines, until recently connected with the Stebbins Engineering and Manufacturing Company, Watertown, N. Y., has opened a consulting engineering office in the Flower Building, Watertown, N. Y.

Edwin Frank has been appointed instructor in mechanical engineering at the University of Illinois, Urbana, Ill. He was formerly in the hydraulic department of Allis-Chalmers Manufacturing Company, West Allis, Wis.

Harold V. Coes, until recently associated with Lockwood, Greene & Company, Boston, Mass., as special principal assistant, has become affiliated with the Sentinel Automatic Gas Appliance Company, New Haven, Conn., as vice-president and general manager.

R. F. Peters has resigned as mechanical engineer of the San Antonio and Aransas Pass Railway, San Antonio, Texas, to accept an appointment as senior mechanical engineer of the division of valuation, Interstate Commerce Commission, with headquarters at Kansas City, Mo.

J. H. Billings, who at the outbreak of the war was in England on his way to Germany to take a years course of study at the University of Berlin, is now taking a course for a master's degree in mechanical engineering at Massachusetts Institute of Technology.

William J. Dyer has terminated his connection with the Honolulu Iron Works Co., Honolulu, Hawaii, after 15 years service as designing and construction superintendent of machinery for the sugar industry, and with a broad practical knowledge of engineering in its various branches, announces the opening of an office as consulting engineer in the Stangenwald Building, Honolulu, Hawaii.

Mr. Alfred E. Kornfeld, who relinquished his connection with "Engineering News" in 1912 after 18 years service, has again become identified with it and as a member of its business staff, with headquarters in New York City.

Mr. H. deB. Parsons has been appointed joint representative of both the Chamber of Commerce and the Society on a special Board of the City of New York to formulate specifications for fire hose and tests for same.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The first meeting of the season was held on October 8. C. W. Naylor, Member of the American Society of Mechanical Engineers, spoke on the benefits derived from belonging to an engineering society. Other speakers were Prof. G. F. Gebhardt, Member of the American Society of Mechanical Engineers, Professors Peebles, Libby, Anderson, and Roesch and L. W. Bunge.

KANSAS STATE AGRICULTURAL COLLEGE

The following officers were installed at a meeting of the Kansas State Agricultural College Student Branch held on October 1: Prof. A. A. Potter, honorary chairman; J. E. Bengston, president; R. A. Shelly, vice president; L. A. Wilsey, secretary; R. L. Swenson, treasurer. R. L. Swenson reviewed the Journals for July, August and September. J. B. Lund, Superintendent of Heat and Power of the Kansas State Agricultural College, gave an interesting talk on the practical problems of heating buildings. Prof. A. A. Potter, Dean of the Engineering Division, gave a short discussion on the functions and various activities of the American Society of Mechanical Engineers, and Professor Reid of the Electrical Engineering Department gave a short address on the importance of college sections of the national engineering societies.

OHIO STATE UNIVERSITY

The first regular meeting of the Ohio State University Student Branch was held on October 7 and the following officers were elected: R. D. Rogers, chairman; P. W. Sheatsley, secretary; F. M. Atwell, treasurer. T. W. Herbst was chosen to take charge of the athletic activities of the branch. The chairman appointed C. L. Brown, C. Lauer, R. M. Matthews and P. W. Sheatsley to serve as a program committee and L. R. Baker, A. R. Furnas and H. D. Winbigler to comprise a social committee. Prof. Wm. T. Magruder, honorary chairman of the branch, spoke of the relation of the branch with the American Society of Mechanical Engineers, and suggested several ways by which benefit from the Society could be increased. Prof. F. E. Sanborn gave an interesting talk on "The Qualities of an Engineer."

RENSSELAER POLYTECHNIC INSTITUTE

The first regular meeting of the student branch of the Rensselaer Polytechnic Institute was held on September 24 at which 23 members of the Junior Class were taken into the branch. The following officers were chosen: C. P. Brown, chairman; B. F. Percival, vice-chairman; H. Thieringer, treasurer; W. Kelly, secretary. D. M. Singer gave an interesting talk on power development at Niagara Falls. This was followed by a discussion by Prof. A. M. Greene, W. S. Powers and H. Thieringer.

UNIVERSITY OF COLORADO

The first meeting of the University of Colorado Student Branch was held on September 23. The meeting was devoted to a discussion of future plans and activities of the branch, of the possibility of increase of membership and the selection of a suitable pin for the branch.

UNIVERSITY OF MINNESOTA

At the October meeting of the University of Minnesota Student Branch, Fletcher Rockwood presented a paper on the "Disposal of Municipal Waste." He described in general the various methods used by municipalities in disposing of garbage and other waste and gave a detailed account of the incinerator system as employed in Minneapolis.

UNIVERSITY OF MISSOURI

The first meeting of the University of Missouri Student Branch was held on September 21 and the following officers were elected: L. L. Leach, chairman; Troy Russell, secretary and treasurer; P. R. A. Nolting, corresponding secretary; and Prof. A. L. Wescott, Stanley Goodman and W. A. Sloss, the governing board. At a meeting held on October 5, Dean Davenport of the School of Commerce addressed the Society on the present financial crisis.

UNIVERSITY OF NEBRASKA

The following officers were elected at a meeting of the University of Nebraska Student Branch held October 3: D. W. Watkins, chairman; R. B. Gillespie, treasurer. Prof. J. D. Hoffman gave a short talk on the American Society of Mechanical Engineers and the benefits derived from being a member of engineering organizations.

WORCESTER POLYTECHNIC INSTITUTE

The organization meeting of the Worcester Polytechnic Student Branch was held on October 2. R. H. Crippen, chairman of the branch, gave a short talk telling what the purposes and aims of the branch were. Charles S. Gingrich of the Cincinnati Milling Machine Company gave an illustrated lecture on "Modern High Production Milling Machine Practice," showing some of the exceptional results gained by experimental work performed in their research laboratory. Among those who took part in the discussion of the lecture were Dr. Ira N. Hollis, President of Worcester Polytechnic Institute; W. W. Bird, Professor of Mechanical Engineering and Director of the Institute Shops; John S. Spence of the Norton Grinding Company; Albert A. Gordon of the Crompton & Knowles Company; Clinton Alvord of the Worcester Loom Company.

EMPLOYMENT BULLETIN

Note: In sending applications stamps should be enclosed for forwarding.

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

POSITIONS AVAILABLE

914 Instructor in machine shop practice for large university in middle west. College man with practical experience preferred.

1035 High grade, practical machine designer, experience in machine, pattern shop and drawing room; one who can make practical designs from a shop standpoint so that goods may be manufactured cheaply and be of such grade as to meet the best of competition. Position permanent for man of ability. Salary according to ability. Location Missouri. Apply by letter.

1036 Massachusetts concern desires young engineer, preferably one with technical education and two or three years shop experience who is willing to start with reasonable salary and work into estimating and planning department. Apply by letter.

1121 A well established company, manufacturing a line of railroad specialties, covering both rolling stock and road bed, desires to add to its output other articles in keeping with present lines.

MEN AVAILABLE

K-1100 Graduate Stevens Institute of Technology, age 44, married, good executive, broad experience in designing and experimenting with internal combustion engines, also thorough knowledge of "service" work for large automobile concern, desires position in or near New York.

K-1101 Junior member, college graduate, three years engineering department of large eastern steel company; two years assistant superintendent and chief engineer large electric company in charge of engineering and construction departments, designing, estimating, erecting and directing work; competent in designing and building power plants, sub-stations, transmission lines, electric cranes and tram cars, coal and ash handling systems, piping layouts, boiler and engine settings and machinery installation, desires position of authority and responsibility with chance for advancement.

K-1102 Junior member, age 29, graduate mechanical engineer, five years experience in design of steam electrical generating equipment; four years as sales engineer; specialist in modern electrical power generation for industrial manufacturing plants, boilers, all types of steam turbines, generators, condensers and auxiliaries, desires position with an engineering, manufacturing or public utility company. Large acquaintance in western Pennsylvania and eastern Ohio.

K-1103 Junior, Cornell graduate, age 26, two years experience in erecting testing and installing compression and absorption refrigerating machines and several years experience as superintendent of street paving and general construction work, desires permanent position which will lead to advancement in sales, executive or general engineering capacity. Location immaterial, eastern states preferred.

K-1104 Mechanical engineer, technical graduate with wide machine shop and mill experience, desires position with large progressive manufacturer. Would consider taking part interest in small but live manufacturing proposition in New England.

K-1105 Technical physicist, M.I.T. graduate in mechanical engineering, can organize and equip physical testing laboratories, and take charge of research problems in turbine or similar work. Interview in Boston the last week of November or in New York at the Annual Meeting.

K-1106 Associate member, age 32, seven years technical training, four years shop apprentice, drafting and designing steam and pumping engines, also two cycle double acting and four cycle oil engines, desires a change. Has held positions as outside engineer, chief engineer and master mechanic. Executive ability in handling men. Location immaterial.

K-1107 Factory superintendent or general foreman with broad experience in modern manufacturing methods can produce results with your equipment; twelve years experience with production efficiency and organizing of shops.

K-1108 Technical graduate in mechanical engineering, three years practical experience including design, shop management, purchasing and sales work. Last employed as superintendent of company making high grade gasolene motors and would like something of similar nature. Salary $1600.

K-1109 Junior, M.I.T. graduate in mechanical engineering, experienced in all branches of building, construction, especially estimating and cost systems, also sales engineer. Location immaterial.

K-1110 Member, graduate mechanical engineer, 20 years experience as designer and draftsman of simplex and duplex steam pumps, desires position as designer or chief draftsman. Best references.

K-1111 Student member, technical graduate with eight years gas engine experience. At present employed as steam engineer but desires gas engine field.

K-1112 Associate-Member, A.S.M.E., Associate, A.I.E.E., graduate Stevens Institute of Technology, age 26, four years with large electrical manufacturer, two years at factory, remainder of time selling and investigating power requirements of factories, making motor recommendations, figuring comparative costs and presenting them in form of reports, experienced in indicating steam engines. At present engaged in manufacturing line but desires sales work.

K-1113 Superintendent with wide experience in modern methods in foundries, machine shops and manufacturing plants, expert mechanic, good executive able to produce maximum results with equipment and men.

K-1114 Junior, graduate mechanical engineer, five years experience in manufacture and design of high grade automobiles, desires position as assistant superintendent with growing concern. At present engineer of tests in automobile factory building its own parts.

K-1115 Member, 18 years experience as draftsman, superintendent and chief engineer, ten years in selling, will go anywhere in the United States north of the Ohio River. Has proved ability in steel casting specialties.

K-1116 Member, age 34, experienced in design and construction of propelling machinery for steam vessels, desires responsible executive position in similar line of work. At present superintendent in large manufacturing concern but prefers marine engineering.

K-1117 Junior, technical graduate in mechanical and electrical engineering, 12 years practical experience in design, construction and maintenance of sub-stations and power houses high voltage design and construction, gas and gasolene engines. At present employed in responsible position. Salary $175. Location New York.

K-1118 Junior, age 38, sales engineer, broad experience in handling high grade mechanical specialties, acquaintance in manufacturing and engineering fields, desires to represent manufacturers in east or middle west. At present employed.

K-1119 Mechanical engineer with eleven years experience in varied manufacturing lines open for engagement.

K-1120 Member, technical graduate, ten years experience in civil, mining and mechanical engineering, wishes extra work in drafting, designing or calculating. At present employed in Philadelphia.

K-1121 Member, technical training as mechanical engineer, as well as shop training as machinist and superintendent; eight years experience conducting an office as designing and contracting engineer, is open for engagement as representative of high grade concern, preferably in field of equipment for the handling of materials. Location Ohio and adjacent states.

K-1122 Junior, experienced in designing and testing air machinery, power plants and determining costs of production, desires position as assistant to manager, superintendent of industrial concern, or sales.

K-1123 Junior, M. I. T. graduate, journeyman machinist, experienced in design, inspecting, research, steam power, repair work and correspondence, desires position with consulting engineers or manufacturing concern, preferably in the South. At present employed.

ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

American Ceramic Society. Transactions, vol. XVI, 1914. *Columbus, 1914.* Gift of Society.

American Society of Agricultural Engineers. Transactions, vol. 6, 7, 1912-13. *Madison, 1912-13.* Gift of Society.

American Society of Mechanical Engineers. Transactions, vol. 35, 1913. *New York, 1914.*

Association of Harvard Engineers. Year Book, 1913. Gift of A. S. M. E.

Business Methods in Municipal Works. *Philadelphia, 1913.* Gift of Department of Public Works of Philadelphia.

Carnegie Endowment for International Peace. Year Book, 1913-14. *Washington, 1914.* Gift of Carnegie Endowment for International Peace.

Carnegie Foundation for the Advancement of Teaching. 6th Annual Report of the President. *New York, 1911.* Gift of Carnegie Foundation for the Advancement of Teaching.

Chemistry of Combustion Applied to the Economy of Fuel. E. W. Dimond. *Worcester, 1867.* Gift of Dr. Tolman.

Elements of Electricity and Magnetism. Wm. S. Franklin and Barry Macnutt. *New York,* Macmillan Co., 1913. Gift of publishers.

The book has been prepared for college use. An attempt has been made "to rationalize our experience of physical conditions and things." W. P. C.

Experiments in the Preservative Treatment of red-oak and hard-maple cross ties. Francis M. Bond. U. S. Dept. of Agriculture, Forest Service, Bull. 126. *Washington, 1913.* Gift of F. M. Bond.

International Railway General Foremen's Association. Proceedings. 10th Annual Convention, 1914. Gift of Association.

Maine. State Water Storage Commission. 3d and 4th Annual Report, 1912, 1913. *Waterville, 1913-1914.* Gift of Geo. L. Fowler.

Manchester Steam Users' Association for the Prevention of Steam Boiler Explosions. Memorandum by Chief Engineer, 1913. *Manchester, 1911.* Gift of Manchester Steam Users' Association.

Master Boiler Makers' Association. Official Proceedings of 7th, 8th Annual Convention, 1913, 1914. Gift of Geo. L. Fowler.

Minnesota Conservation and Agricultural Development Congress, March 16-19, 1910. Address delivered at St. Paul, 1910. Gift of A. S. M. E.

National Paving Brick Manufacturers' Association. Directions for laying Vitrified brick street pavements. No. 1 Specification. *1911.*

——— Specifications for the construction of vitrified brick street pavements and vitrified brick highways. Gift of Association.

New Jersey Board of Public Utility Commissioners. 4th Annual Report, 1913. *Union Hill, 1914.* Gift of New Jersey Public Utility Commissioners.

New York State Engineer and Surveyor. Supplement to the Annual Report. vol. II, 1913. *Albany, 1914.* Gift of State Engineer and Surveyor.

Nouvelles Recherches sur la Résistance de L'Air et L'Aviation. G. Eiffel. 2 vols. *Paris, Dunod et Pinat, 1911.* Gift of author. (Review will appear in next issue of Journal.)

Poor's Manual of Industrials, 1914. *New York, 1914.*

Proportioning Aggregates for Portland Cement Concrete. Albert Moyer. Gift of Vulcanite Portland Cement Co.

Science Museum (South Kensington). Catalogue of the Mechanical Engineering Collection. Part I, and supplement. *London, 1914.* Gift of Science Museum.

Scientific Management. A collection of the more significant articles describing the Taylor system of management. Edited by Clarence Bertrand Thompson. *Cambridge, Harvard University Press, 1914.* Gift of author.

This is the first of the series "Harvard Business Studies," issued by the Graduate School of Business Administration. Among the numerous articles reprinted are several from the Transactions of the Society. Over eight hundred pages of reprints are given, preceded by a paper on the literature of scientific management, and followed by a good bibliography of the subject. An extremely useful compilation. W. P. C.

Some Tests to Determine the Effect upon Absorption and Penetration of Mixing Tar with Creosote. F. M. Bond. Gift of author.

South Philadelphia. The abolishment of grade crossings and the creation of opportunities for commercial and industrial development. *Philadelphia, 1913.* Gift of Department of Public Works of Philadelphia.

U. S. Commissioner of Corporations on Transportation by Water in the United States. Report. Pts. I-IV. *Washington, 1909, 1910, 1913.* Gift of U. S. Dept. of Commerce and Labor.

Voltage Testing of Cables. W. I. Middleton and C. L. Dawes. *1914.* Gift of Simplex Wire & Cable Company.

Wisconsin Industrial Commission. Building Code. 1914. *Madison, 1914.* Gift of Commission.

EXCHANGES

Brooklyn Engineers' Club. Proceedings for 1913. *Brooklyn, 1914.*

Institution of Civil Engineers. Minutes of Proceedings. vol. CXCV. *London, 1914.*

Charter, supplemental charters, by-laws and list of members. July, 1914. *London, 1914.*

Municipal Engineers of the City of New York. Proceedings, 1913. *New York, 1914.*

Purdue University. Alumni Register. 1875-1911. *Lafayette, [illegible].*

U. S. Commissioner of Patents. Annual Report. 1913. *Washington, 1914.*

TRADE CATALOGUES

Baird Machine Co., *Bridgeport, Conn.* Bull. 303. Ball burnishing machine.

Bryant Electric Co., *Bridgeport, Conn.* Bryant silent call signal system for hospitals. 31 pp.

Durand Steel Locker Co., *Chicago-New York.* Catalogue E. Steel racks, shelving, factory equipment. Catalogue F. Steel lockers.

Goldschmidt Thermit Co., *New York, N. Y.* Reactions. Third quarter, 1914, no. 3.

Johns-Manville Co., *Cleveland, O.* The J-M roofing salesman. September, 1914.

Leschen & Sons Rope Co., *St. Louis, Mo.* Leschen's Hercules, September, 1914.

Timken Roller Bearing Co., *Canton, O.* Timken magazine. August, October, 1914.

Under-Feed Stoker Co. of America, *Chicago, Ill.* Publicity Magazine, September, October, 1914.

Walworth Mfg. Co., *Boston, Mass.* Model piping specifications. September, 1914.

UNITED ENGINEERING SOCIETY

American Library Association. Handbook, 1914. (vol. 8, no. 5, of Bulletin.) *Chicago, 1914.* Gift of W. P. Cutter.

A Magyar Mérnökés Epitész-Egylet 1914. *Budapest, 1914.* Gift of the American Society of Hungarian Engineers.

Motion Picture Trade Directory, August 1914. *New York, 1914.* Gift of Frank Wenneis.

New International Encyclopaedia. ed. 2. vols. 3-6. *New York, 1914.*

New Zealand Patent Office Journal. vol. 1; vol. 2, nos. 1-8, 10-13, 15-25; vol. 3, nos. 1-4, 6-11. *Wellington, 1912-14.* Gift of Patent Office.

Oil, Paint and Drug Reporter. Green Book for Buyers, January 1914 edition. *New York, 1914.* Gift of Oil, Paint and Drug Reporter.

Passenger Car Ventilation System of the Pennsylvania Railroad Company. Chas. B. Dudley. *Altoona, 1913.* Gift of Pennsylvania Railroad Company.

Patents. Chas. L. Clarke. Reprinted from "General Electric Review." Gift of author.

Publishers' Trade List Annual, 1914. *New York, 1914.*

Who's Who in America. vol. VIII, 1914-15. *Chicago, 1914.*

TRADE CATALOGUES

Bartlett & Snow Co., *Cleveland, O.* Catalogue no. 29. Garbage disposal plants. 1909. Bulletin no. 40. Garbage disposal machinery. Zopp.

Crown Cork & Seal Co., *Baltimore, Md.* The Crown cork system. 55 pp.

Griscom-Russell Co., *New York, N. Y.* Bulletin 703. Rubbish utilization plant in the city of Pittsburgh, Pa. 704. Report of official tests of Sterling Destructor installed at Halifax, N. S. The Sterling Destructor. 48 pp.

Hammond Engineering Co., *Warren, Pa.* Sewage disposal.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

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H. R. Cobleigh, House Committee

Leonard Waldo, Library Committee

L. P. Alford, Committee on Meetings

Theo. Stebbins, Committee on Membership

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Fred J. Miller, Public Relations Committee

R. H. Rice, Research Committee

Jesse M. Smith, Committee on Constitution and By-Laws

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New Haven: H. B. Sargent
New York: R. V. Wright
Philadelphia: H. E. Ehlers
San Francisco: Robert Sibley
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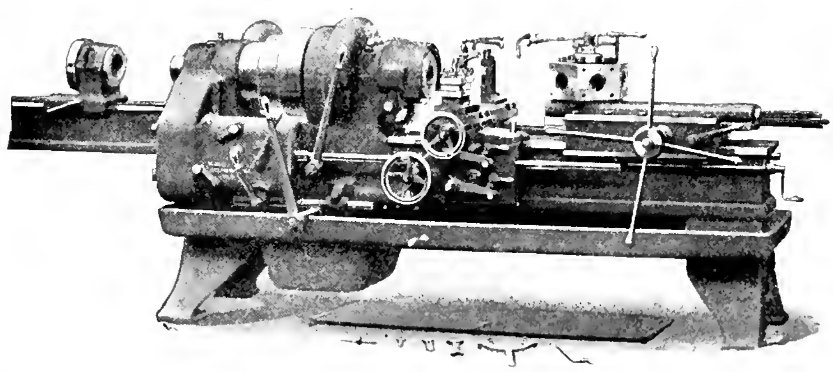
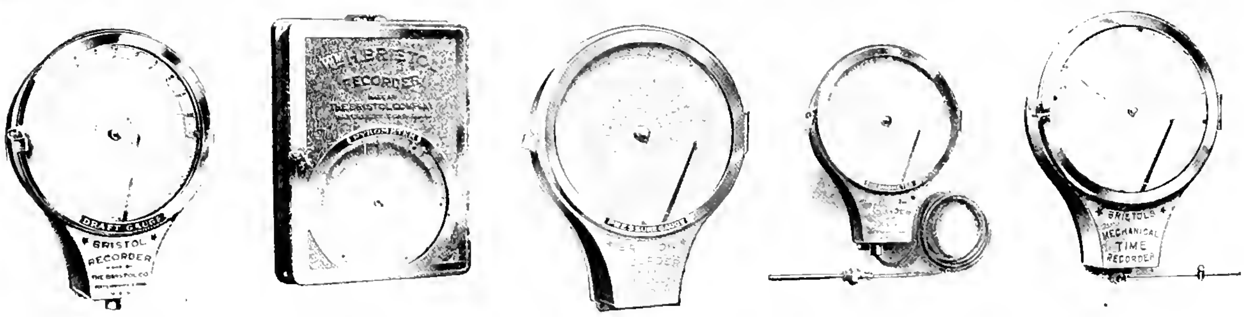
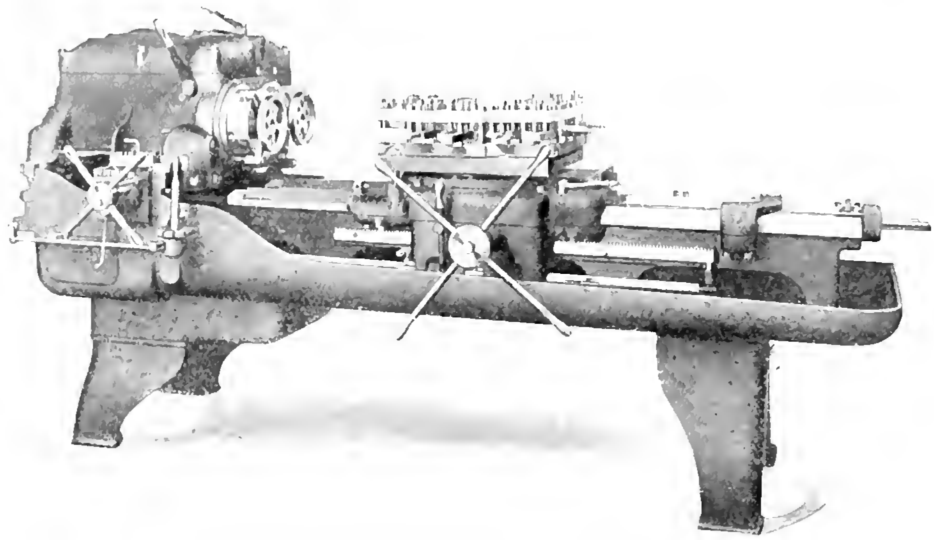
[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1914, and in the January and July 1914 issues of The Journal

Advertising Section





EFFICIENCY FEATURES



The Double Spindle Flat Turret Lathe for Chuck Work. Range, using two spindles, 10″ swing; single spindle, 17″ swing.

Do you know why the work done on a Jones & Lamson Turret Lathe maintains a uniform degree of accuracy throughout the entire lot—whether it's 1000 pieces or 50,000—allowing, of course, for wear of the cutting edge of the tool?

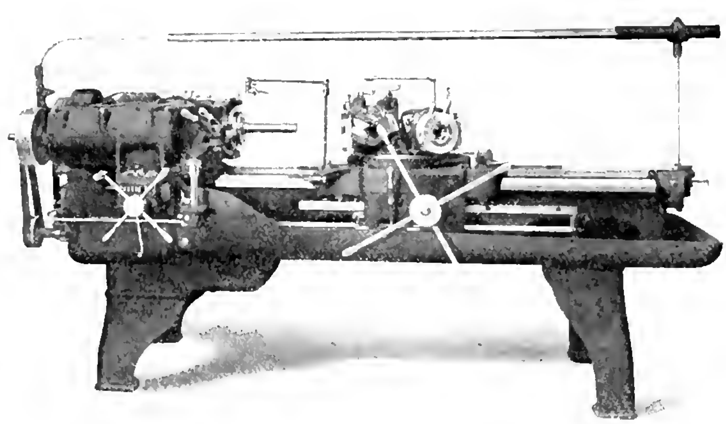
If you have used other makes of turret lathes on large quantity lots, you, very likely, have noticed the variation of shoulder lengths on the finished work. The reason for this is insufficient stop mechanism.

With the ordinary stop mechanism, when the feed is released, there is a rebound action, due to the reduction of feed pressure against the work and backlash in the gears or screw. This rebound action not only leaves an imperfect shoulder on the work but usually scores the finished piece.

That objectionable feature is overcome on the Jones & Lamson Turret Lathe by means of the Friction Feed Mechanism—an exclusive J. & L. feature.

On pages 2 and 3 of The Journal of The Am. Soc. M. E., August issue, we described the simple stop mechanism and the method of obtaining the wide range of feeds and speeds by means of a slight shift of a single controlling lever.

On the next page, of this issue, we have described the Friction Feed mechanism which insures accurate duplication and by means of the "Rattler Gear," prevents idle machinery.



3″ x 36″ Flat Turret Lathe for Bar and Chuck Work—Range on bar work—up to 3″ diameter and 36″ length. Chuck work up to 14″ swing.

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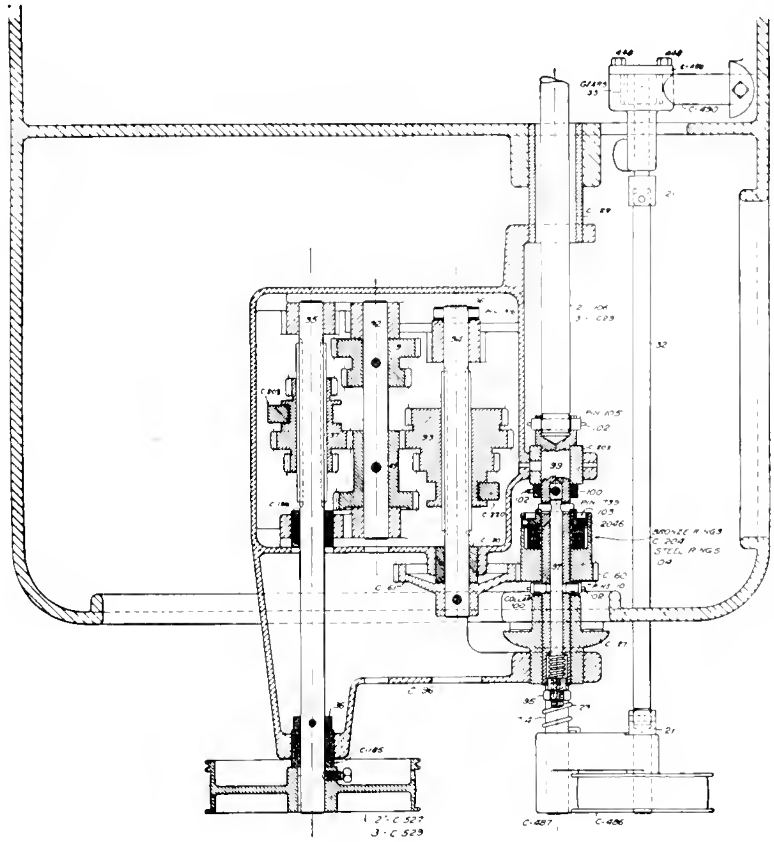
OF EFFICIENT MACHINES



There are many distinctive features on the Jones & Lamson Turret Lathes which go to make Turret Lathe Efficiency. These characteristics are the development of more than half a century of concentrated effort in the perfection of the turret lathe.

In the above illustration note part "C-60" called the "Rattler Gear." This "Rattler Gear" is an ingenious device for notifying the operator when the tool has finished the cut and acts as a housing for the steel and brass rings "104 and 204" forming the friction feed mechanism.

This friction feed mechanism—used exclusively on Jones & Lamson Turret Lathes—performs the very important duty of keeping a predetermined pressure on the cutting tool when the Turret Carriage or Cross Feeding Head reaches the stop.

The pressure exerted by the Friction Feed keeps the tool firmly against the stop until the shoulder on the work is finished to exact size; then the "Rattler Gear" notifies the operator, by means of a clicking noise, that the cut is finished. The desired driving power of the friction feed is governed by the adjusting nut, No. 95, which acts as a binder on the discs and once adjusted, it requires no further attention.

With other makes of turret lathes the operator is obliged to perform the work of the friction feed on the J. & L. and the fact that he does not exert a uniform pressure on each piece, partly accounts for the variation of shoulder lengths on the finished work, therefore, the value of this friction mechanism should readily be appreciated.

The gear box showing the multiple, sliding gears in section, is the unique, compact, variable feed mechanism used to obtain nine changes of feed, ranging from 20 to 120 per inch and controlled by a single lever directly in front of the operator. The mechanism, controlling these multiple gears, was fully described in The Journal of The Am. Soc. M. E. as noted on opposite page.

The advantages of a J. & L. are so numerous that we cannot begin to enumerate in this space. If you are interested in a turret lathe and desire further facts and reasons for J. & L. supremacy, send for our catalogue, or better still, have our representative call—no obligations—we're glad to have the opportunity.

MACHINE COMPANY

97 QUEEN VICTORIA STREET
LONDON, E. C.

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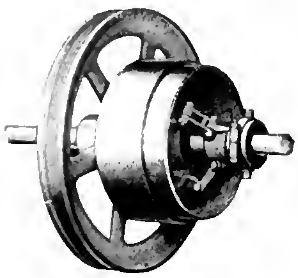
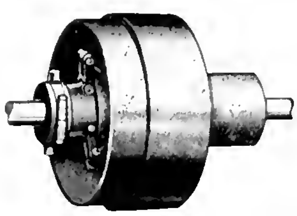
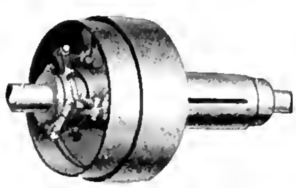
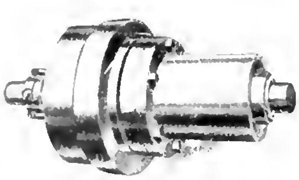
Friction Clutches Friction Clutch Pulleys
Friction Clutch Couplings
For All Speeds


Friction Clutch Sheave Wheel


Friction Clutch Cut Off Coupling


Friction Clutch with Sleeve


Friction Clutch with Ball Bearing Sleeve

The illustrations on this page show our standard line of High-speed Friction Clutches.

Having had 29 years' experience in building Friction Clutches for all classes of work we recently put on the market a standard line of High-speed Friction Clutches to meet all requirements of leading Engineers in this and other countries.

The chief difficulty encountered with Clutches for high speed work has been the lubrication problem. We have eliminated this difficulty and made our Clutch so that it is impossible for it to throw oil due to centrifugal force. When oil is thrown from a Clutch your Belting and other materials are soon destroyed. This feature alone makes our Clutches especially adaptable for use in food factories, flour mills, textile mills, paper mills and laundries.

They are designed so as to meet the laws for preventing accidents. All moving parts are self-contained and free from dust or any foreign substance.

The simplicity of construction of Moore & White High-speed Clutches makes expert mechanical knowledge unnecessary to understand the principles of adjustment and operation. The discs in these Clutches are made of bronze and thereby give a longer life than wood-filled Clutches as used for ordinary service up to 400 R.P.M. All parts are interchangeable, designed for severe service, and for operating at the least possible upkeep expense.

The particular advantage of all Moore & White Friction Clutches, and the reason they are used exclusively by many leading engineers, is due to their mechanical stability, starting power, simplicity.

When selecting a Friction Clutch it is well to choose one backed by a house of established reputation.

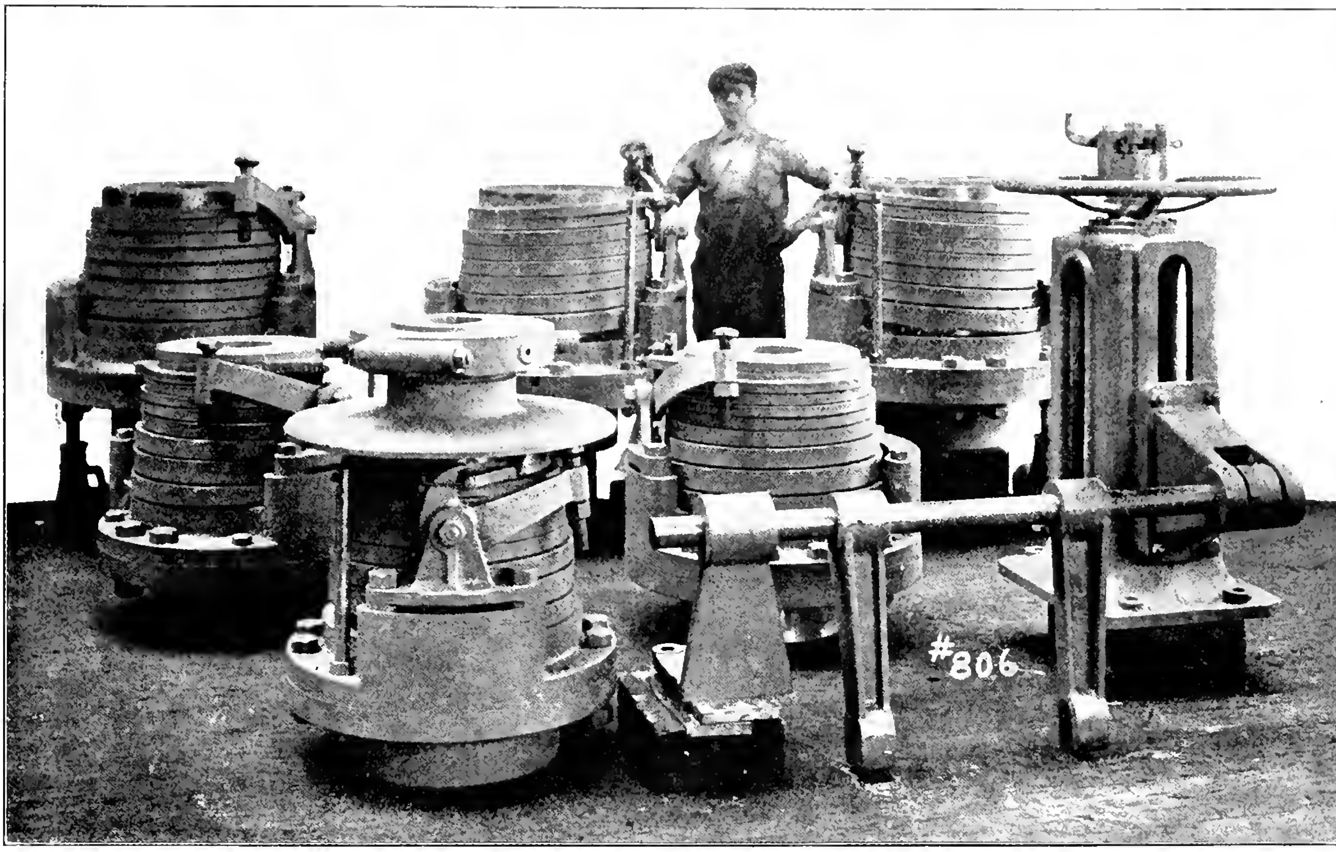
Our 1915 Friction Clutch Catalog is now ready for distribution. Send for your copy.

The Moore & White Co.

Established 1885

PHILADELPHIA, PA.

FARREL



A group of Coil Friction Clutches for the heads of Rubber Mill Lines. The Coil Friction Clutch is especially adapted to the transmission of High Power at the slower speeds

Catalogue on request

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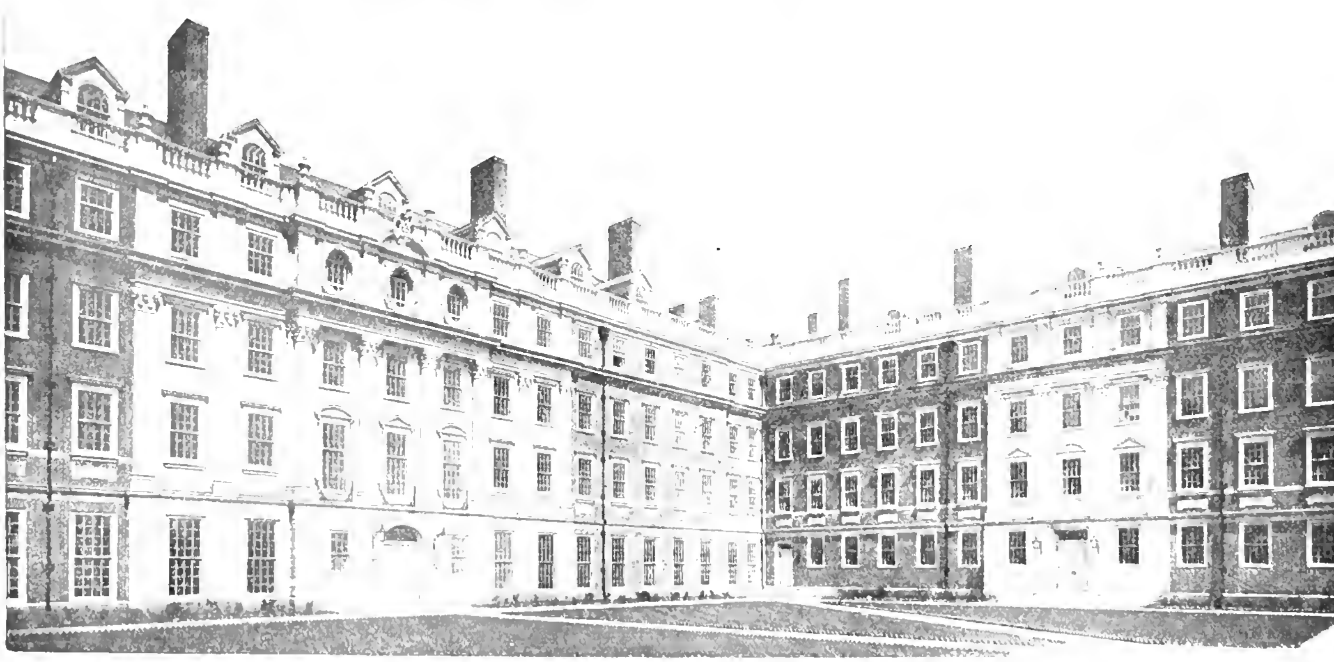
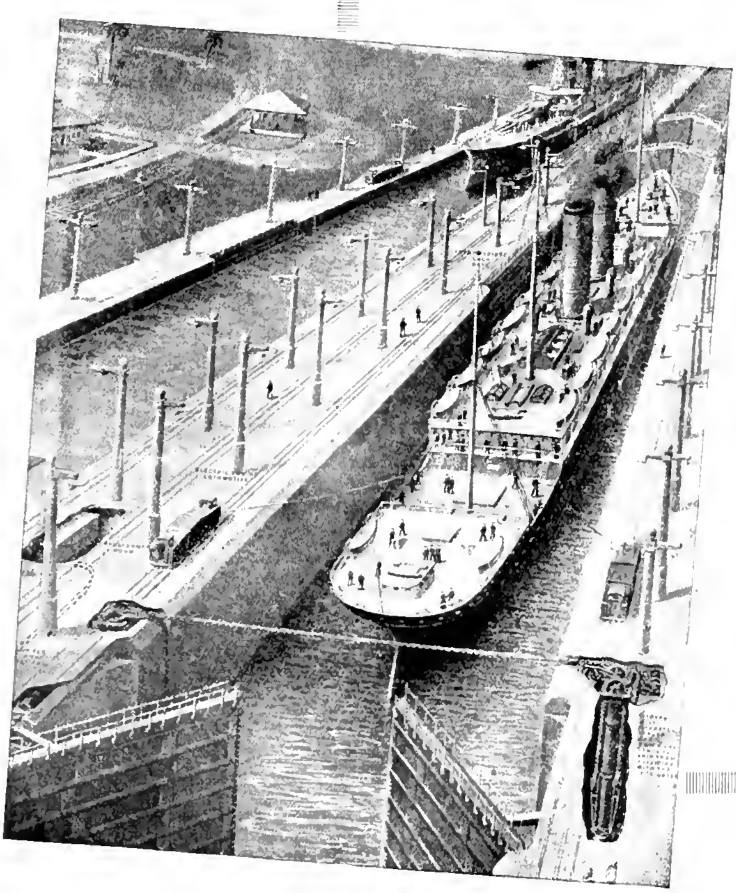




Panama Canal Valves Tested to 2500 Pounds

The 46 Nelson Steel Hydraulic Operating Valves like those shown below are not only unique in themselves, but serve one of the most remarkable purposes for which valves have ever been built.

These valves are known as "Chain Fender Machine Operating Valves." They operate the cylinders that raise and lower the great chains that are thrown across the Panama Canal locks to prevent ships entering the locks from coming in contact with the lock gates.

Should a vessel get out of control and ram the gates, springing them enough to prevent their opening, it might block the entire canal, and should the impact be sufficient to drive open the gates, permitting the water to escape, the vessel's back would undoubtedly be broken on the floor of the lock below.

The fender chains are made from the highest quality wrought iron bar 3″ in diameter, each link tested to 275,000 lbs.; the cylinders, 20 feet in length and 40 inches in diameter, are of the finest steel. And consistently, the valves that admit the water to the cylinder through 6-inch mains are

NELSON Valves

"A Safe Valve Investment"

The working pressure in the machines is to be approximately 150 lbs., but the valves were constructed and tested to withstand a pressure of 2500 pounds per square inch in emergency.

Throughout the length and breadth of the Canal each detail has received the same careful consideration. No inferior product has been allowed to wedge its way in. The selection of Nelson Steel Valves to protect the most important feature of the entire canal, is a splendid tribute which should impress every user of valves for any purpose with the truth that "NELSON VALVES" are "A Safe Valve Investment."

Tell us the purpose for which you need valves

NELSON VALVE COMPANY

7612-20 Queen St. Chestnut Hill
PHILADELPHIA

Pounds of Steam— Or Grate Area?

Do you decide the size of steam and water boilers by grate area—that vague measure of capacity—or by pounds of steam guaranteed at the radiators?

Deciding in terms of grate area may call for a large boiler because the fire surfaces may not be of highest efficiency. A smaller boiler, having a more effective form and arrangement of fire surfaces and a better ratio of heating surface to grate area, should supply just as much steam or hot water and be less expensive.

When you specify size of grate you ignore quality of fire surface; when you specify boiler rating you take advantage of good design.

The above explains one reason for using.

Mills Water Tube Boilers

They are rated in *pounds of steam supplied to the radiators*, and the water-tube fire surfaces give greatest capacity with given dimensions of grate.

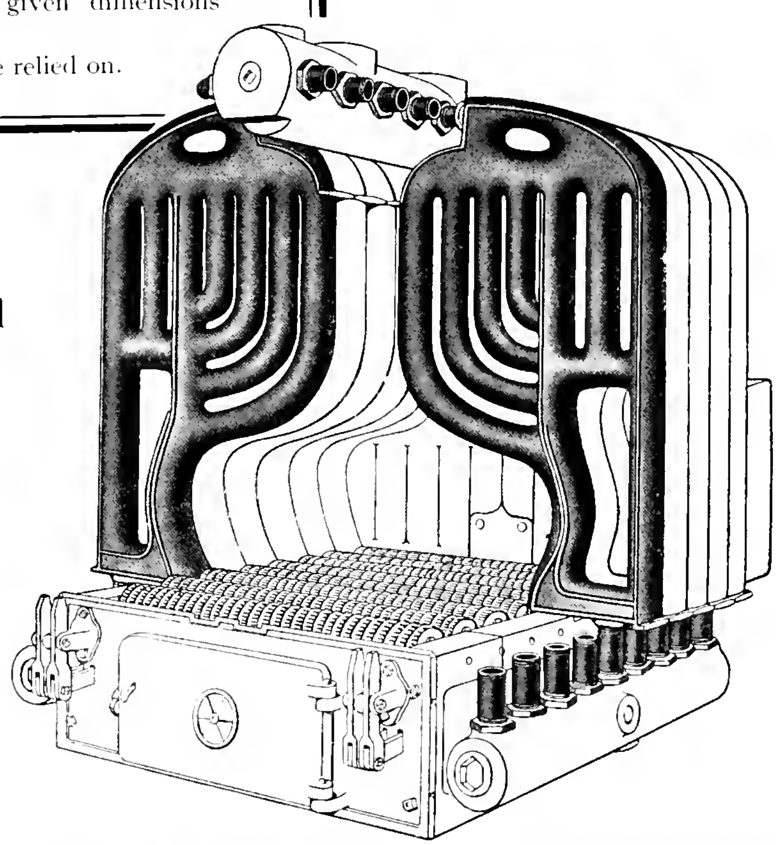
Catalog No. 946 can be relied on.

The water-tube construction with all connecting nipples outside

makes it easy to add sections to a boiler if it proves too small—

permits blanking off a section if it becomes disabled—

eliminates interior joints in cramped places.



The H. B. Smith Company

Westfield, Mass.

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39 East Houston St.

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1225 Arch St.

BOSTON:
138 Washington St., North

SOME ENGINEERING PHASES 167

The type of underfeed stoker which has met with favor, especially in the larger power stations in the East, has its tuyere blocks for air admission inclined from the front of the furnace toward the bridge wall, and has its

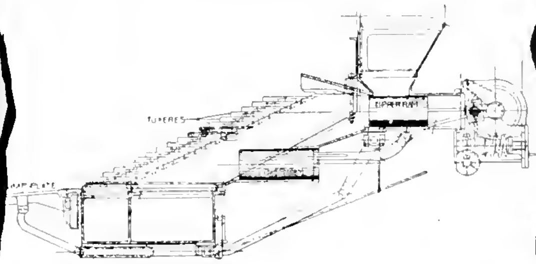
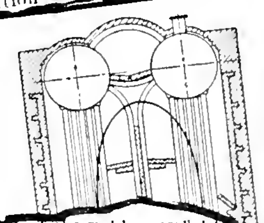


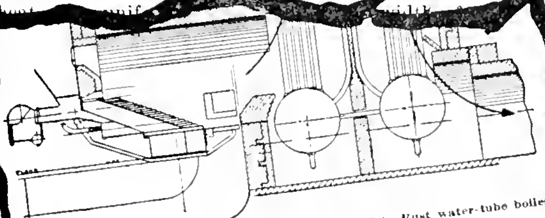
Figure 55—Longitudinal section of underfeed stoker, Taylor model.

retorts formed between the tuyere blocks and placed across the front of the furnace. The coal is fed to the furnace from a hopper placed across the front of the furnace, as illustrated by Figure 55. It feeds from ... gravity to two rams ... the advantage of positive ... underfeed stoker has ... operation is independent of weather draft, and hence its operation



...e 58—Underfeed stoker, Taylor model, as applied to ... water-tube boiler.

smaller installations. This stoker has the advantage over the hand cleaned type, that provision has been made for cleaning the fire instead of being compelled to rake the clinker out by hand. The inclining of the tuyeres and provision for cleaning the fire also permit of the installation of a larger number of smaller retorts, which distribute



...re 60—Underfeed stoker, Taylor model, as applied to Rust water-tube boiler.

... It meets changes of load quickly, and on test conditions. ... has shown that boilers can be brought from a standstill to a high rating in a very short time. This stoker affords a means for increasing both economy and capacity of plants, which, by gradual growth, have added so many

Some ... the more important factors, a consideration of which will enable the manufacturer to obtain efficient and smokeless operation of his plants, are: Remodeling along proper lines the poorly constructed installations, and replacing old and worn out installations with modern apparatus is highly important; centralized stations of ample size should replace the numerous, small and scattered boiler plants; and hand-fired furnaces should be eliminated in plants of more than 300 horsepower capacity. In addition to these it is highly important that the equipment be maintained at its maximum operating efficiency at all times, that careful and scientific supervision of operating methods be provided, and, that maximum efficiency from the operating force might be secured, working conditions should be of the highest order obtainable under existing circumstances.

The Taylor Stoker

Endorsed by Experts

THE TAYLOR STOKER has received emphatic enough endorsement through installation and use in the generating stations and manufactory boiler plants of the country,—but it has probably never gained such positive published endorsement from an expert source as appears in the Bulletin No. 8, just published, of the Mellon Institute of the University of Pittsburgh, entitled "Some Engineering Phases of Pittsburgh's Smoke Problem."

This is a publication of over 150 pages based on a thorough investigation of 157 boiler plants in Pittsburgh; the conclusion reached is that the underfeed stoker is the best means not only for smoke elimination but also for increase in efficiency and fuel economy.

The remarks pointedly referring to the TAYLOR STOKER are shown to left; they need no comment. Only note particularly that the TAYLOR is marked off as superior to all others because it embodies the self-cleaning principle. Note also the judgment that all plants of over 300 h.p. should, in the statement of investigators, be stoker equipped.

We ask any Consulting Engineer, manufactory or power station interested in smoke elimination *accompanied* by reduction in coal consumption and increase in efficiency, to inform themselves respecting this system.

American Engineering Co.

PHILADELPHIA

HEINE

The Day Is Here

"The day will come when permanent soot blowers will be installed with every boiler just as stop valves are installed."

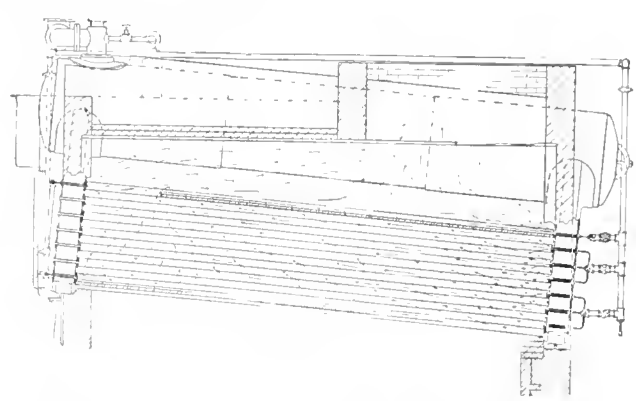
The above paragraph is taken from an article by Mr. Charles H. Bromley, of the Editorial Staff of *Power*.

Mr. Bromley is right. Every boiler should be equipped with a permanent soot blower.

The Heine Boiler

Is always installed with a complete and efficient soot blowing system, consisting of small steam nozzles inserted through the hollow stay bolts of the rear header, with auxiliary nozzles at the top and bottom of the front header.

This simple soot blowing system is possible with the Heine Boiler because the baffling is horizontal and the soot may be blown parallel to the tubes. Incidentally this system requires no openings in the side walls of the setting and thus eliminates loss by air in-leakage.



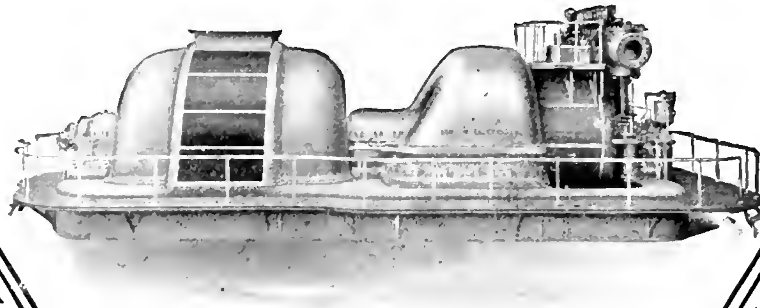
For information on soot blowing with Heine Boilers, send for our special pamphlet "Boiler Cleaning Logic."

HEINE SAFETY BOILER CO.

2465 East Marcus Ave.

ST. LOUIS, MO.

CURTIS TURBINES



RELIABILITY

ECONOMY

Closely Linked

CURTIS TURBINES
RELIABILITY
CLOSELY LINKED
ECONOMY

CURTIS TURBINES
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ECONOMY

The 12,500 Kw. turbine shown above is one of several now in operation at the Hauto plant of the Lehigh Navigation and Electric Company.

These are the most efficient turbines of their size so far placed in commercial operation.

These machines are typical of the standard line of turbines, covering all sizes manufactured by the General Electric Company.

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For Texas, Oklahoma and Arizona business refer to Southwest General Electric Company (formerly Hobson Electric Co.), Dallas, El Paso, Houston and Oklahoma City. For Canadian business refer to Canadian General Electric Company, Ltd., Toronto, Ont.

5194

Reduce Costs and Promote Factory Efficiency

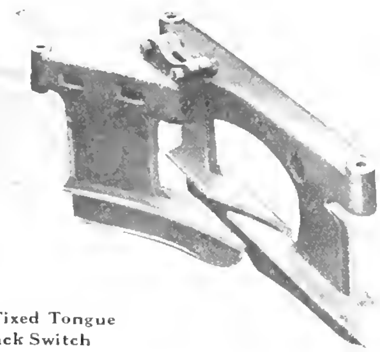
Shaw F. T. Electric Monorail System

The Shaw "F-T" Electric Monorail System is DIFFERENT.

The term "F-T" signifies the **FIXED TONGUE** in the track switch—no moving part—nothing to set—no open ends.

These distinctive features of the Shaw Monorail System establish the **SAFETY** and **EFFICIENCY** of the overhead monorail for Factory Transportation.

SAFETY—Owing to the absence of any open ends in the track system, derailments are impossible and no "safety appliances" are required.



The Fixed Tongue Track Switch

EFFICIENCY—No time is lost at the switches—the Shaw Monorail Hoist is "dirigible" and runs through the switches without stopping—the operator in the cab controls the route as well as the hoisting and travel motions.

Heretofore the weak point in the Overhead Monorail has been the track switch, but with the Shaw System the Track Switch is an advantage instead of a draw-back.

The Shaw "F-T" Monorail Hoist is built with the ordinary single lift or with double lift for handling long material; also for Grab Bucket operation.

Send for Our Illustrated Bulletin 73-B

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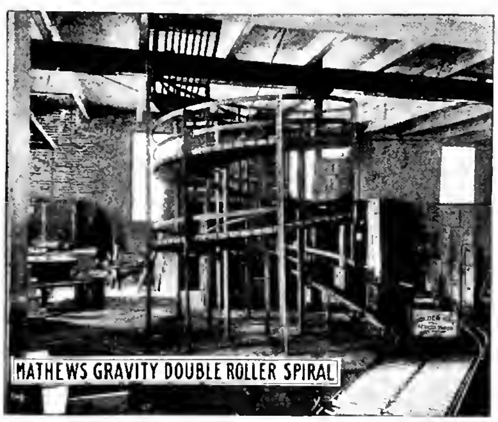
Attention of Mechanical Engineers

Cut out this coupon, attach it to your letter head and we will mail our full set of catalogs and bulletins illustrating and describing the Mathews line of Standard Equipment, consisting of Gravity Conveyers, Automatic Elevators, Gravity Roller Spirals, Gravity Spiral Chutes, etc. Sooner or later you will have use for the information given in our literature.

THE MATHEWS STANDARD ORIGINAL LINE OF CONVEYERS



MATHEWS GRAVITY DOUBLE ROLLER SPIRAL

Labor-Saving, Cost-Cutting CONVEYER EQUIPMENT

For All Handling Purposes
Specify MATHEWS' CONVEYERS
THE OLDEST AND BEST-KNOWN LINE

MATHEWS STEEL BALL-BEARING GRAVITY CONVEYER

Gravity Roller Conveyers,
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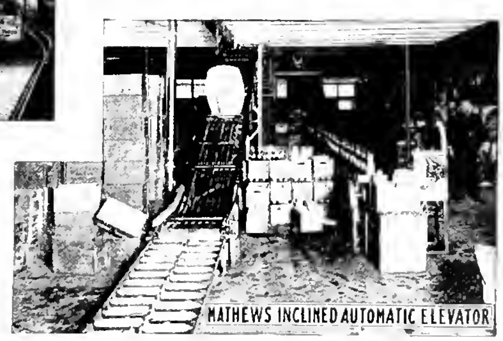
Branch offices in all leading American cities with competent consulting engineers in charge.



MATHEWS INCLINED AUTOMATIC ELEVATOR

SPEED — MATHEWS GRAVITY CARRIER COMPANY — The Mathews Way — The Saving Way — ECONOMY

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Jenkins Bros. Valves

for Modern High Pressure Power Plant Service

High Pressure adds unusual wear and tear to the ordinary requirements of a valve. It is not alone important to consider what test pressure a valve will bear, but also to know under what working pressure a valve can safely be used in constant service. Jenkins Bros. Valves were very carefully designed, mindful of the importance of having every part fully capable of withstanding the severe stresses incident to high pressure service. The iron body valves as illustrated, **Jenkins Bros. Extra Heavy Globe Valves, Flanged, with By-Pass,** are guaranteed entirely suitable for working steam pressures up to 250 pounds, with an ample factor of safety, and tested up to 800 pounds hydraulic pressure. The bodies, yokes and disc holders are made of high-grade cast iron; the spindles, renewable seat rings and renewable discs of durable steam metal composition.

For *high pressure superheated steam* these valves are made with bodies and yokes of cast steel, and the spindles, seat-rings, and disc-rings of Monel Metal. The Cast Steel valves are suitable for working steam pressures up to 350 pounds, and total temperature of 800 degrees F.

Write for catalog descriptive of the complete line of Jenkins Bros. Valves and Mechanical Rubber Goods

The Diamond
Trade Mark
Is Your Protection

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This 100,000,000 gal. DE LAVAL

Steam-Turbine-Driven Centrifugal Pump

is installed for water works service in a large city. It was chosen in preference to all other types because of the lower annual operating expense, including both steam cost and interest, upkeep and depreciation charges. It does not require a large and expensive building, nor heavy and costly foundations. Because of the absence of vibration, it can be operated at full capacity when jacked up on blocks, as shown in the picture. Because of the absence of plunger packings and valves, the efficiency will be maintained, and expense for attendance and repairs reduced. All parts subject to wear are interchangeable and are cheaply and quickly renewable.

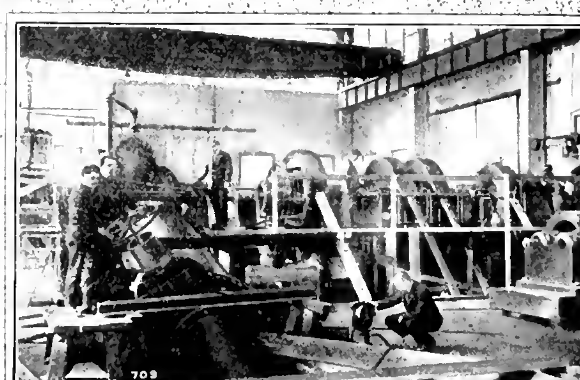
If interested in pumping matters, send for our new 300-page Treatise B58.

DE LAVAL

Steam Turbine Co.

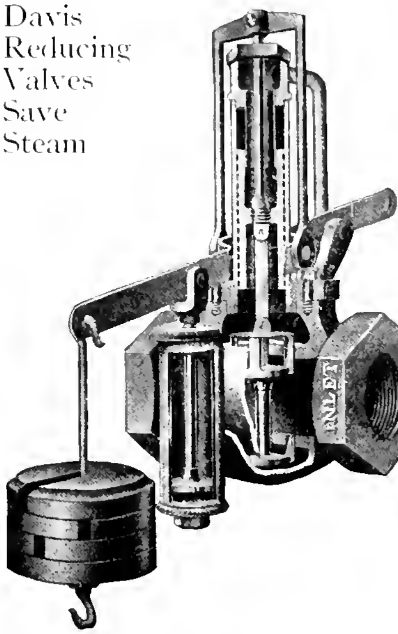
Trenton, N. J.

139



The Davis Reducing Valve

Davis
Reducing
Valves
Save
Steam



Send for Catalog No. 8 showing the full line of Davis Valve Specialties.

FOR automatically maintaining less than boiler pressure on your heating system, cooker, dry-kiln, pump, small engine or other apparatus, you want a Davis Reducing Valve.

This well designed, accurately made valve has a successful record of forty years back of it. It was the first good reducing valve made in this country and it is more in demand today than any other make.

Simplicity makes for efficiency. This valve has no diaphragm, springs, toggles, packing or small ports. Its principle of operation is the balancing of pressure by counter-weights—the simplest and most dependable construction possible.

Having a perfectly balanced disk, the Davis Regulator is not affected by fluctuations in the high pressure. It will maintain a constant reduction to within a fraction of a pound, regardless of variations in the boiler pressure.

Get a Davis the next time you buy a reducing valve. It is fully guaranteed.

G. M. Davis Regulator Company

439 Milwaukee Ave. Chicago, Illinois

New York Boston Philadelphia Pittsburgh San Francisco

LUNKENHEIMER

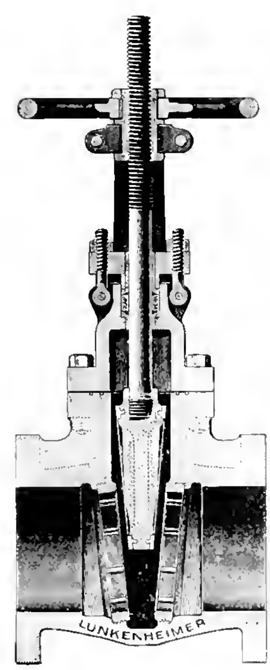
"VICTOR" GATE VALVES

Made in Medium and Extra Heavy **Bronze** Patterns; Standard, Medium, Heavy and Extra Heavy **Iron Body Bronze Mounted** Patterns, and in **"Puddled" Semi-steel** and **Cast Steel**; with Rising Stem and Yoke, or Stationary Stem; with or without By-pass, in all standard sizes and for various pressures.

The complete line of Lunkenheimer High Grade Engineering Specialties includes, besides the above, **Bronze** and **Iron Body Bronze Mounted** Globe, Angle, Cross, Check, Non-return Boiler Stop, Throttle, Blow-off, Pop Safety, Relief, Screw Down Check Valves, etc.; Water Columns, Gauges and other Boiler Mountings; Whistles and Ground Key Work of all descriptions; Injectors, Ejectors, Lubricators and Lubricating Devices; Oil Pumps, Oil and Grease Cups; Gas Engine Specialties, etc.

Your local dealer can furnish them; if not, write us.

For a complete description of the entire line, see Lunkenheimer Catalogue No. 50. Write for a copy.



THE LUNKENHEIMER CO.

"QUALITY"

Largest Manufacturers of High Grade Engineering Specialties in the World

CINCINNATI, OHIO

New York - Chicago - Boston - London

6-46

Venturi Accuracy is Demonstrated in the Leading Technical Schools

The fact that the leading technical schools and colleges throughout the country have permanent Venturi testing equipment installed illustrates their high opinion of this form of measurement for boiler feed and other service. The illustration shows the students of Drexel Institute at Philadelphia, demonstrating the high accuracy of the Venturi by weighing the feed water on platform scales. A 2" Venturi Meter Tube connected with a Type M Indicator-Recorder performs the dual service of continuously checking the efficiency of the boilers and also providing an instructive exercise in power plant economy. This meter has been installed since 1912 and its two years of service measuring hot water at very high temperatures is proof of Venturi accuracy and durability.

Students Testing Venturi Meter at Drexel Institute, Phila.

Among other well known Venturi-equipped technical schools and colleges are:

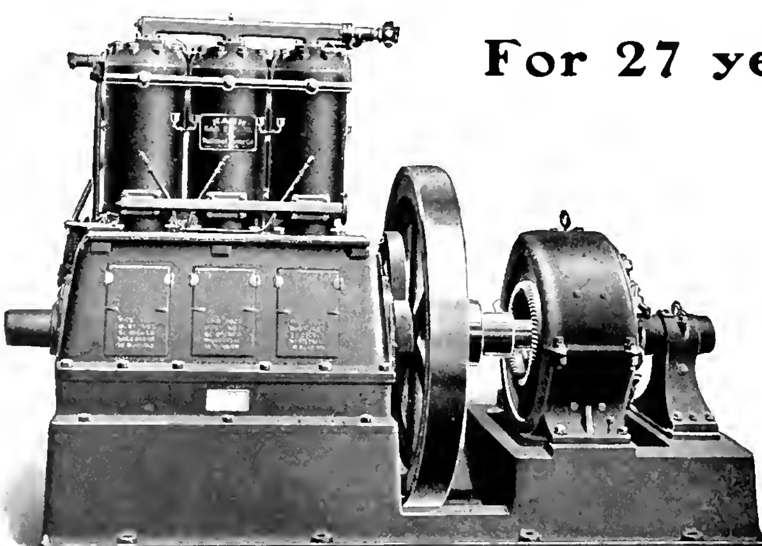
Massachusetts Institute of Technology
Worcester Polytechnic Institute
Lehigh Institute
Harvard University
Brown University
Case School of Applied Science
Michigan Agricultural College
University of Texas
University of Illinois
Leland-Stanford University
Johns Hopkins University

Why not avail yourself of the experience of these laboratories? A Venturi meter would improve your boiler plant economy. Write for Bulletin No. 68 M. Yours without obligation.

Builders Iron Foundry, "Builders of the Venturi," **Providence, R. I.**

New York Pittsburgh Chicago San Francisco Portland Seattle

THE NASH ENGINE



For 27 years the leader in Vertical Gas Engine Design

Specially adapted for

Electric Generation
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NATIONAL METER COMPANY

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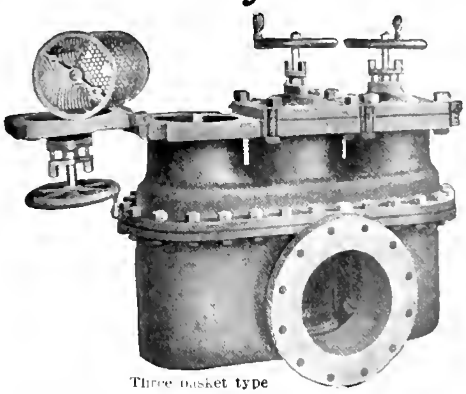
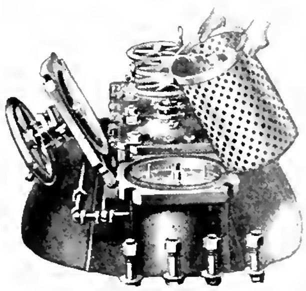
LAGONDA MULTIPLE STRAINERS

Pay Interest on the Investment



Three basket type



Removing basket for cleaning

FISH, leaves, sticks and other solids in the supply water clog the water boxes and tubes of condensers, and decrease the condensing surface and volume of water passing through the condenser. A drop in the vacuum and a reduction in the load capacity of the plant, is the result. Clogged condensers of reduced capacity, or those that have to be shut down for cleaning, do not pay interest on the investment. **Constant, efficient operation for any machine means dividends.**

With a Lagonda Multiple Water Strainer in the supply line, the water flows through straining baskets, which removes all solids and prevents their passing on to the condensers and pumps.

The straining baskets in operation have an effective straining area of two to four times that of the supply line. Each basket can be removed for cleaning and carried away to be emptied, without interruption to the operation or causing a dirty mess around the machine.

Lagonda Multiple Strainers are built in sizes from 2" to 48" for all types of pumping engines, condensers and general service pumps.

Write for Bulletin R-2.

The Lagonda Mfg. Co.
SPRINGFIELD, OHIO
NEW YORK, BOSTON, PHILADELPHIA, ST LOUIS, CHICAGO, DETROIT
FUEL SAVING SPECIALISTS
DALLAS, SAN FRANCISCO, ST PAUL, MONTREAL, LONDON

Makers of Lagonda Boiler Tube Cleaners, Automatic Cut-off Valves, Reseating Machines, Boiler Tube Cutters and Water Strainers

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A Visit to the Power Plants

of the largest and best-known manufacturers in the country will show you that

GOULDS POWER PUMPS

are the choice wherever engineers are employed to keep down maintenance and operating costs and to insure uninterrupted service.

That's why such concerns as

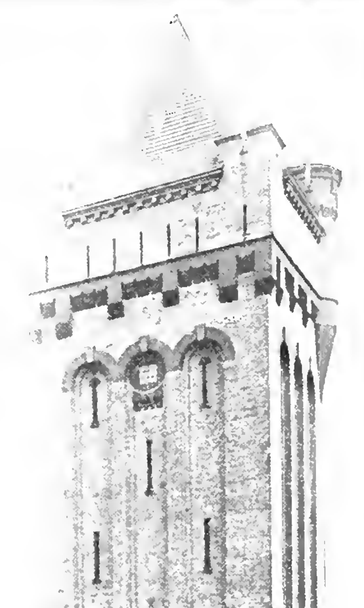
WESTERN ELECTRIC COMPANY—World's largest manufacturer of telephone apparatus
GENERAL ELECTRIC COMPANY—World's largest electrical manufacturer
TIMKIN ROLLER BEARING COMPANY—World's largest manufacturer of roller bearings

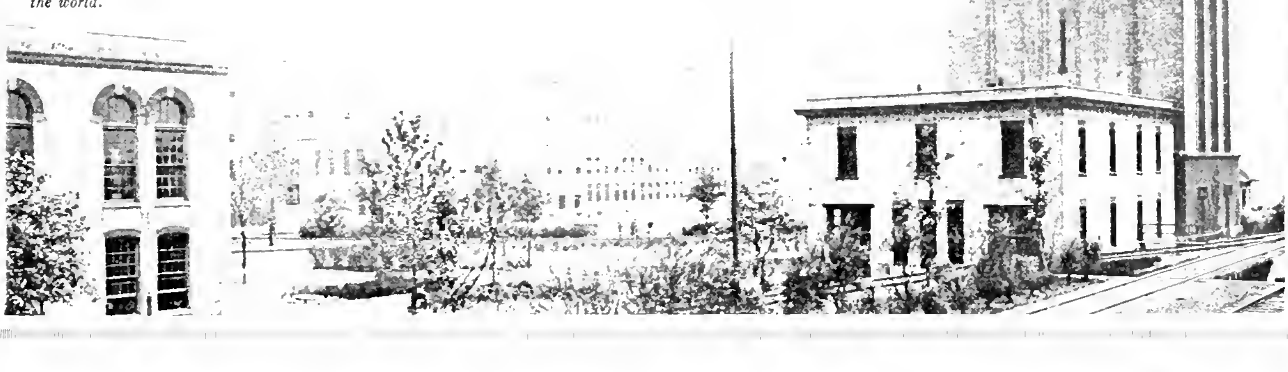
and many others of world wide reputation are Goulds Pump users. If you want the same pump service these manufacturers get all you need do is specify Goulds.

Ask for copy of our book "How and Where Pumping Costs Can Be Reduced."

Partial view of the 150 acre, Hawthorne, Ill., plant of the Western Electric Company, largest manufacturer of telephone apparatus in the world.

The Goulds Manufacturing Company
78 West Fall St. Seneca Falls, N. Y.



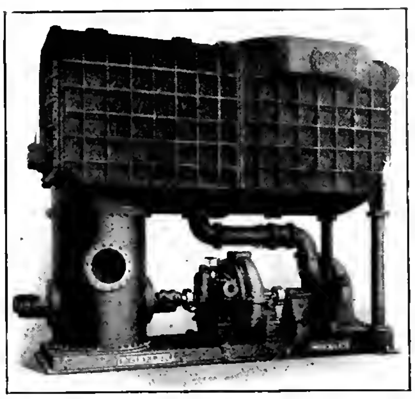


WHEELER

Counter-Current Jet Condenser

With Complete Turbine-Driven Auxiliaries

The photograph below shows the latest improvement in counter-current jet condensers of the well-known Wheeler Rectangular Rain Type. The steam entrance is at the top, permitting the location of the condenser beneath the turbine.



The entire auxiliaries are grouped beneath the condenser and are driven by one turbine located in the center. At one end is the tail pump and at the other the Turbo Air Pump. The tail pump is of the submerged type, insuring the removal of the water under the most adverse conditions of entrance head.

The Turbo Air Pump is of the well-known Wheeler type with large capacity for free air and ability to maintain the vacuum under abnormal air leakage.

For further information on Wheeler Rain Type Counter-current Jet Condensers, send for our new Bulletin J-107.

WHEELER

CONDENSER & ENGINEERING CO.

CARTERET, NEW JERSEY.

"Pioneer American Condenser Builders"

122

THE VALVE SEAT TELLS THE STORY

IN BLOWING ENGINES AND COMPRESSORS FOR AIR AND GAS, FREE VALVE AREA DETERMINES THE EFFICIENCY AND SAFE ECONOMICAL PISTON SPEED.

THE LARGE FREE AREA OF THE **MESTA PLATE VALVE (IVERSEN PATENT)** IS SHOWN BY THE DARK SECTION IN THE ILLUSTRATION. IT IS MADE POSSIBLE BY THE METHOD OF PERMANENTLY FASTENING THE SPRING AND VALVE PLATE TOGETHER, WITHOUT TAKING UP ANY AVAILABLE FREE AREA.

COMPARE THE FREE AREA OF OUR VALVE SEAT WITH THAT OF ANY OTHER PLATE VALVE ON THE MARKET, REFERRING BOTH TO THE SAME OUTSIDE DIAMETER OF VALVE.

MESTA PLATE VALVES ARE SUITED EQUALLY WELL FOR HIGH SPEEDS AND FOR LOW SPEEDS. THE VOLUTE SHAPE OF THE SPRING AND THE RELATIVE PROPORTIONS OF THE VALVE PLATE, SEAT, AND GUARD MAKE POSSIBLE REMARKABLY LOW SPEEDS WITHOUT FLUTTERING OF THE VALVE.

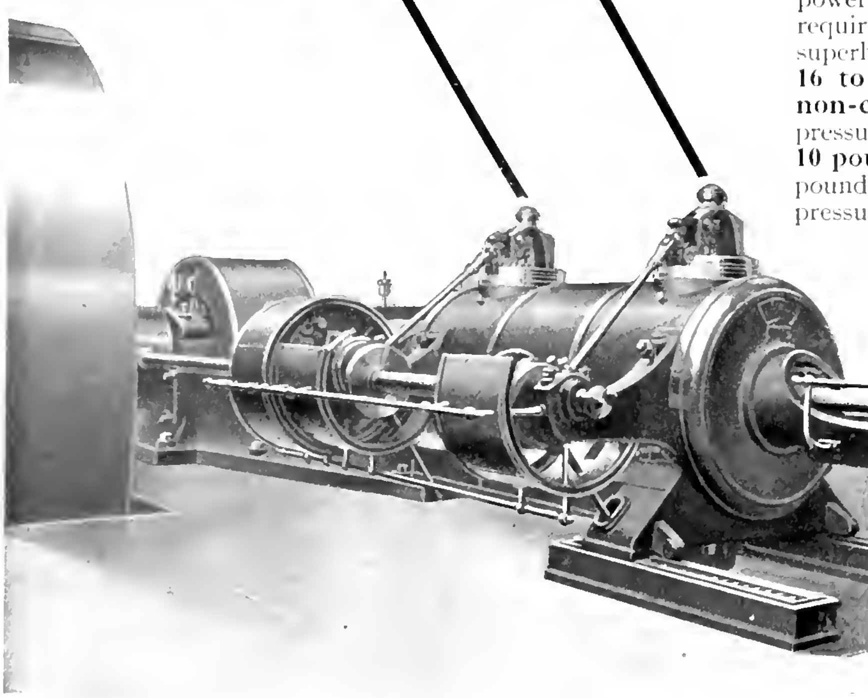
(WRITE FOR BULLETINS H, Ha & N)

MESTA MACHINE COMPANY

PITTSBURGH, PA., U. S. A.

DESIGNERS AND BUILDERS OF GAS AND STEAM ENGINES, ROLLING MILL MACHINERY, CONDENSERS, AIR COMPRESSORS, ETC.

NORDBERG
Poppet Valve Engines



The Nordberg High Speed Poppet Valve Engine, single-cylinder, non-condensing

THE Nordberg Mfg. Co. has built Poppet Valve Engines for high steam pressures and superheat for over 20 years.

Some of the first engines built are still in operation.

Recently a large number of Poppet Valve power engines have been built for modern requirements of high boiler pressures and superheat. Economies are guaranteed of **16 to 22 pounds per horse power hour, non-condensing,** depending upon the boiler pressure, back pressure and superheat, and **10 pounds per horse power hour,** for compound condensing engines with high boiler pressure, superheat and 26″ vacuum.

Compound engines have high pressure cylinders of the poppet type, and low pressure cylinders of the Corliss type, this combination giving the highest combined efficiency.

For further information on Nordberg Poppet Valve Engines, send for our New Bulletin 25. Also ask for Bulletins on Corliss and Uniflow Engines.

Nordberg Mfg. Company
Milwaukee, Wisconsin

Manufacturers of High Efficiency Corliss Engines; Uniflow Engines; Poppet Valve Engines; Air Compressors; Blowing Engines; Hoisting Engines; Pumping Engines; and other machinery. 9

NORDBERG MACHINERY

FULTON
Oil and Steam Engines

Are Backed by Our Reputation for Reliability
"Sixty Years of Successful Manufacturing"

We build our machinery complete in our own plant. Long experience has demonstrated the proper materials to be used in our castings and our workmanship is of the highest class.

Fulton-Tosi Oil Engines, Diesel Type

Fulton-Corliss, Medium and High Speed Engines

Write for Oil Engine Bulletin "A."

FULTON IRON WORKS

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You Can "See" It

TEXACO HONOR OIL can be "seen" on the guides and on the ends of bearings.

It cannot be rubbed off, squeezed out, or splashed off from bearing surfaces. It is a thorough lubricant with the proper body.

TEXACO HONOR OIL is ready for the work as delivered. It banishes for all time the expensive and all too prevalent practice of "doping" up machine oils with costly cylinder oil.

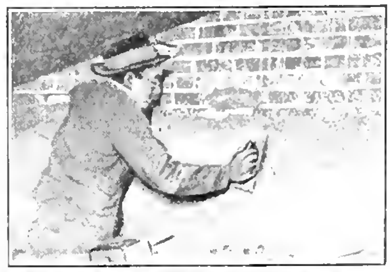
Find out more about TEXACO HONOR OIL. It comes from a fine family.

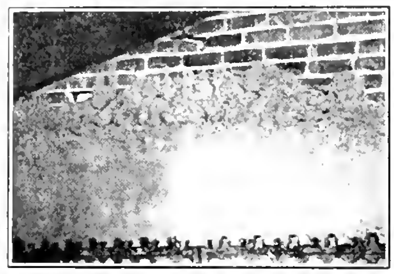
TEXACO

THE TEXAS COMPANY

DEPARTMENT M. E.

17 Battery Place New York City





Putting Betson's Plastic Fire Brick In Place

For further information regarding these One Piece Linings see page 75 of the 1914 edition of Condensed Catalogues of Mechanical Equipment, published by The American Society of Mechanical Engineers

Betson's One Piece Gas and Air Tight Linings have shown their superiority through years of continuous service. Proving their economy in cost of upkeep and low fuel consumption.

Betson Plastic Fire Brick Co.

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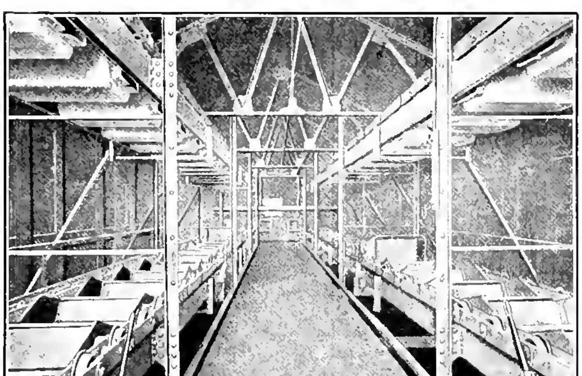

Upper Runs of the two "Hunt" Noiseless Pivoted Bucket Conveyors, L. S and M. S. Railway Co. Coaling Station, Toledo, Ohio

The "Last Word" in Locomotive Coaling Stations

EQUIPPED WITH

"HUNT" MACHINERY

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West New Brighton, N. Y., U. S. A.

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Our First Grade, Backbone Center Stock Belt

IT is impossible to build a better belt than our Cocheco. Into this grade go the finest leather and the most careful and expert workmanship possible to imagine.

Since we started making Cocheco 71 years ago we have held it at the same high standard, refusing at all times to attempt to meet vicious price cutting by lowering its quality. Belt buyers know that, whether procured last year, this year or next year, the quality is always the same.

It is not low priced belting, neither is its cost exorbitant. We simply put into this belting the very best of stock and workmanship and sell it on the closest of margins. Belting buyers everywhere testify to its economy and reliability.

I. B. WILLIAMS & SONS

DOVER, N. H.

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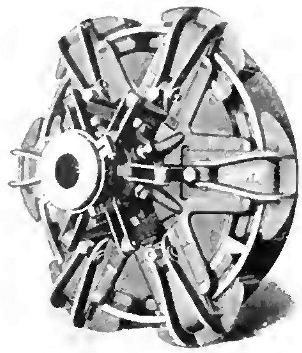

6-Arm Friction Clutch Coupling

FALLS Transmission Machinery is the result of a generation of technical research for obtaining proper efficiency. Falls Clutches are dependable with minimum frictional losses.

Full and complete line of

Bearings, Couplings, Head Shaft Hangers, Floor Stands, Base Plates, Etc.,

Designed for service and durability.

Our Engineers are specialists on equipments for the economical distribution of power, and are always at your service.

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CUYAHOGA FALLS, OHIO

(Branches)

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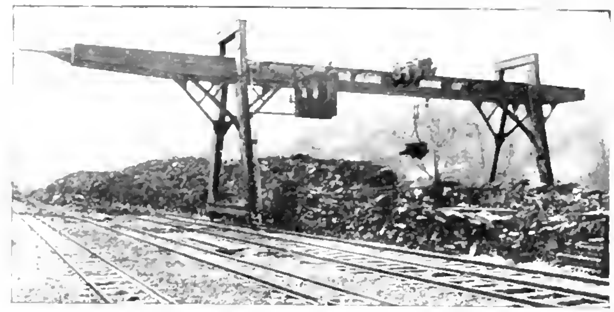

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Double Cantilever Gantry Crane, Magnet Type

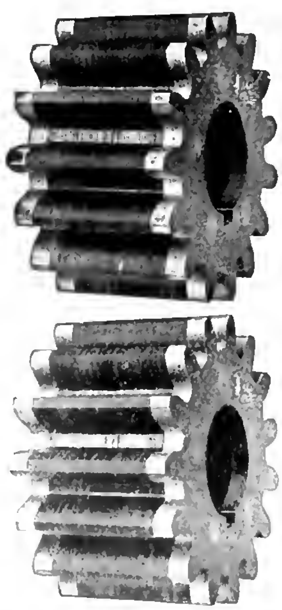
Specially adapted to service in the stock yards of steel plants and wherever it is desirable to have a storage space in the middle and railroad tracks under the cantilevers.

Built in any span and capacity and for any service; either magnet or grab bucket type. Let us know exactly what your crane requirements, either present or prospective, are, and we shall be pleased to make estimates.

PITTSBURG *The Largest Manufacturers of the Worlds Largest Cranes* NEW YORK

THE ALLIANCE MACHINE CO.
ALLIANCE, OHIO.
BIRMINGHAM **ENGINEERS AND BUILDERS** CHICAGO

Inside the Border is a Complete List of the Objectionable Gear Noises Present Where *New Process Noiseless Pinions* are Used.



Surely this is better than the ringing, rattling, roaring, shrieking, nerve-racking sounds from metal-to-metal gear contacts.

Send for and read our booklet "Noiseless Gear Driving"

NEW PROCESS IS TO ALL OTHER RAWHIDE AS STEEL IS TO IRON

NEW PROCESS GEAR CORPORATION

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CANADIAN AGENTS: Robert Gardner & Son, Ltd. Montreal

A Splendid Machine

for logging operations, handling sand, etc., is this

O.S. LOCOMOTIVE

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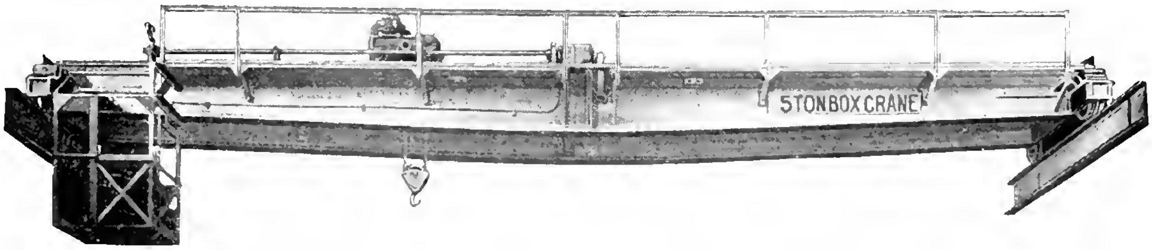
One of the many types illustrated in Bulletin No. 9 which is worth writing for.

10 Ton - 8 Wheel Locomotive Crane

Orton & Steinbrenner Co.

Main Office: CHICAGO, ILL.

ELECTRIC & HAND POWER CRANES, PORTABLE ELECTRIC & MONORAIL HOISTS



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AUBURN

Trade Mark

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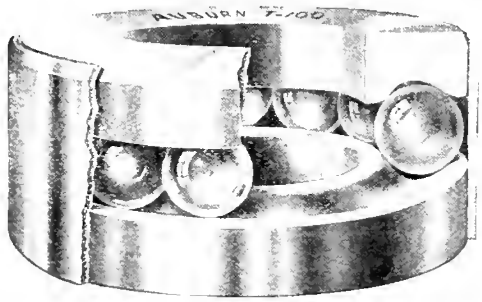

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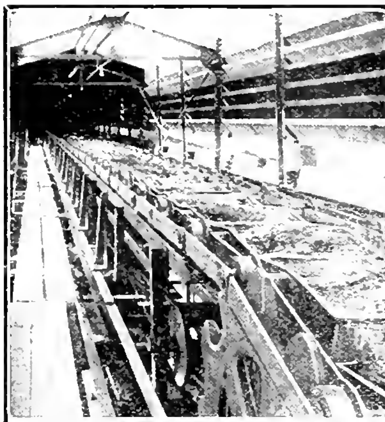
STEEL, BRASS AND BRONZE BALLS

Put your problems up to us, or ask for bulletins

AUBURN BALL BEARING COMPANY — 20 Elizabeth Street, Rochester, N. Y.



Upper Run of Jeffrey Pivoted Bucket Elevator-Conveyer

An Ideal Combination Elevator and Conveyer

Requires Minimum Power Consumption, Maintenance Expense, and Attention

JEFFREY PIVOTED BUCKET ELEVATOR-CONVEYERS

are especially adapted for Boiler House and Cement Mill Service.

Made in several sizes for small, medium and large capacities.

The pivot connection permits the buckets to carry their loads in a level position with the conveyer running in straight lines, curves, or at any angle to the horizontal or vertical

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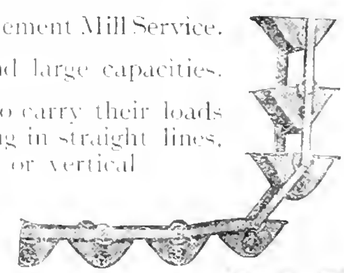

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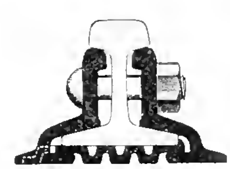
Continuous Rail Joint

Over 50,000 miles in use

Weber Rail Joint

Rolled from Best Quality Steel



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The Rail Joint Company

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Makers of Base-Supported Rail Joints for Standard and Special Rail Sections, also Girder, Step or Compromise, Frog and Switch, and Insulated Rail Joints, protected by Patents.

Highest Awards—Paris, 1900; Buffalo, 1901; St. Louis, 1904.

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ALMY WATER TUBE BOILER CO.
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Manufacturers of Almy Patent Sectional Water Tube Boilers for steamships, river steamers, both propeller and stern wheel, torpedo boats, fire boats, launches. Donkey Boilers for steamships and for all kinds of stationary work.

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AMERICAN STEAM GAUGE AND VALVE MFG. CO.
BOSTON, MASS.
ESTABLISHED 1851

Pressure and Recording Gauges, Engine Room Clocks and Counters for all purposes. Iron and Brass Pop Safety and Relief Valves for stationary, marine and locomotive use. The American Thompson Improved Indicator with new improved detent motion. The American Ideal Steam Trap.

See pages 110, 111 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume*.

Valves

Gauges

Indicators

W. N. BEST
11 BROADWAY NEW YORK CITY

Apparatus for and technical information relative to all forms of liquid fuel equipment

Oil and Tar Burners

Furnaces

CHAPMAN VALVE MANUFACTURING CO.
INDIAN ORCHARD, MASS.
BOSTON NEW YORK ST LOUIS PITTSBURGH CHICAGO PHILADELPHIA SAN FRANCISCO

Brass and Iron Valves for steam, water, gas, oil, etc. Sluice Gates. Send for catalogue.

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CRESCENT MANUFACTURING CO.
SCOTTDALE, PA.

Lackawanna Sight Feed Lubricators and Automatic Grease Cups

Lubricators

Grease Cups

EDGE MOOR IRON COMPANY
EDGE MOOR, DELAWARE

Builders of the Edge Moor Water Tube Boiler. Especially suitable for large power plants. Steel construction, straight tubes, all hand holes elliptical, unrestricted circulation which permits forcing fires with safety and economy.

See page 23 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume*

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ERIE CITY IRON WORKS
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Boilers: water tube, horizontal tubular, return tubular, water bottom portable, open bottom portable, vertical tubular and vertical water tube. Engines: Erie City "Lentz," four valve, enclosed high speed, automatic, center crank, side crank, portable and Feed-Water Heaters from 25 to 600 h p.

Steam Boilers and Engines

Feed-Water Heaters

HARRISBURG FOUNDRY & MACHINE WORKS
HARRISBURG, PA.

Manufacturers of Fleming-Harrisburg Horizontal Engines, Corliss and Single Valve, Simple, Tandem and Cross Compound.

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HOMESTEAD VALVE MANUFACTURING CO.
WORKS: HOMESTEAD, PA.
PITTSBURG, PA.

Manufacturers of "Homestead Valves." Straightway, Three-way and Four-way, for blow-off or for highest pressure and most difficult service for water, air or steam. Valves unlike all others.

See page 82 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume*.

Valves

WALWORTH MANUFACTURING CO.
BOSTON, MASS

Manufacturers of high grade Brass, Iron and Steel Valves, Power Plant Piping; Screwed and Flanged Fittings; Pipe Fitter's Tools. Genuine Stillson Wrenches, Parmelee Wrenches, Walco-Hex Wrenches.

Valves
Power Plant Piping
Wrenches

POWER TRANSMISSION
HOISTING AND CONVEYING MACHINERY

THE BROWN HOISTING MACHINERY CO.
CLEVELAND, O. U. S. A.
NEW YORK SAN FRANCISCO
PITTSBURGH CHICAGO MONTREAL

Designers and Manufacturers of all kinds of Hoisting Machinery including Locomotive Cranes, Electric Travelers, I-Beam Trolleys, Crabs, Winches, etc., as well as heavy Hoisting Machinery of all descriptions. Also Ferroinclave for reinforced concrete roofing.

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Hoisting Machinery

H. W. CALDWELL & SON COMPANY
NEW YORK CHICAGO

Elevating, Conveying and Power Transmitting Machinery. Helicoid and screw conveyors, machine molded gears, pulleys, fly-wheels, rope sheaves and drives, sprocket wheels and chain, buckets, belting, shafting and bearings.

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Conveyors
Elevators
Power Transmission

DODGE MANUFACTURING COMPANY
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Everything for the Mechanical Transmission of Power, Elevating and Conveying; and Water Softeners. Write for "Power Transmission Engineering," the most complete book of its kind published. It will help you in your specifications.

Transmission Machinery
Water Softeners
Rope Drives
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THE EASTERN MACHINERY COMPANY
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Manufacturers of Electric and Belt Power Passenger and Freight Elevators, Hoisting Machines, Friction Winding Drums, Friction Clutches and Friction Clutch Pulleys.

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Friction Clutches
Pulleys

THE FAFNIR BEARING COMPANY
NEW BRITAIN, CONN

High grade Ball Bearings made of the finest materials to the closest standards of accuracy in the world. Fafnir Ball Bearing Hanger Boxes can be used in any standard hanger frame.

Ball Bearings

THE HILL CLUTCH COMPANY
CLEVELAND, OHIO

Manufacturers of a complete line of Power Transmission Machinery for belt, rope or gear driving, including the well known Hill Friction Clutches and Hill Collar Oiling Bearings.

See page 156 of Condensed Catalogues of Mechanical Equipment, 1913 Volume

Power Transmission

LIDGERWOOD MFG. CO.
96 LIBERTY ST. NEW YORK

Hoisting Engines—steam and electric, for every use of the contractor, miner, warehouseman, railroads, shipowners, etc. Derricks, Derrick Irons and Derrick Hoists, Cableways for hoisting and conveying, Marine Transfer for coal and cargo handling.

Hoisting Engines
Cableways
Marine Transfers

LINK=BELT COMPANY
PHILADELPHIA CHICAGO
INDIANAPOLIS

Elevators and Conveyors for every purpose; all accessories; Power Transmission Machinery. The Link-Belt Silent Chain Drive, Coal Tipples, Coal Washeries, Locomotive Cranes, etc.

See page 192 of Condensed Catalogues of Mechanical Equipment, 1913 Volume

Elevators and Conveyors

Cranes

THE MORGAN ENGINEERING CO.

ALLIANCE OHIO

Are the largest builders of Electric Traveling Cranes in the world. We also design and build Steel Plants complete, Hammers, Presses, Shears, Charging Machines and all kinds of Rolling Mill and Special Machinery.

Robins Belt Conveyors

ROBINS CONVEYING BELT COMPANY

13 PARK ROW NEW YORK

The Robins Belt Conveyor was the original and is today the standard of this type of conveying machinery. It is successfully and economically conveying ore, rock, coal and similar materials under the most trying conditions of service. Correspondence invited.

See page 193 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Pulleys

Paper Friction Transmission

THE ROCKWOOD MANUFACTURING CO.

1925 ENGLISH AVE.
INDIANAPOLIS IND

Rockwood Paper Frictions have proven their unquestioned superiority. You will find our booklets regarding Transmission of Power by Belts and Friction Transmission desirable additions to your engineering library. Furnished free to members upon application.

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Mono-Rail Systems

SHAW ELECTRIC CRANE CO.

MUSKEGON MICH

Address 119 W. 40th St., New York, (*See Manning, Maxwell & Moore, Inc.*)

Electric traveling Cranes for all purposes. Gantry Cranes. Wharf Cranes and Winches. Mono-Rail Systems.

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THE TOLEDO BRIDGE & CRANE CO.

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Toledo Cranes and Hoists; Coal and Ore Handling Bridges; Grab Bucket Machinery; Electric and Hand Power Cranes, all types, any capacity; Structural Steel for Factory Buildings.

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THE WEBSTER M'F'G COMPANY

(Successors to WEBSTER M'F'G CO.) TIFFIN, OHIO
EASTERN BRANCH: 88-90 READE ST NEW YORK

Manufacturers of Elevating, Conveying and Power Transmitting Machinery for all purposes. Over thirty years' experience in this line and extensive facilities for manufacturing give us large advantages. Belt Conveyors for handling cements, ores, sand, gravel, etc. Coal and Ash Handling Systems for power plants and buildings. Chain belting. Gearing.

Power Transmission

T. B. WOOD'S SONS CO.

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Modern and Approved Appliances for the transmission of Power. Shafting, Couplings, Collars, Hangers, Pulleys, Belt Tighteners, Friction Clutches, Rope Driving Equipments.

See pages 154, 155 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

STEEL WORKS AND ROLLING MILL EQUIPMENT

Engines

Rolling Mill Machinery

MACKINTOSH, HEMPHILL & CO.

PITTSBURGH PA

Engines, single and compound, Corliss reversing and blowing. Rolling Mill and Hydraulic Machinery of all kinds. Shears, Punches, Saws, Coping Machines.

Blast Furnace Blowing Engines

WEIMER MACHINE WORKS COMPANY

LEBANON PA

Builders of Blast Furnace Blowing engines and equipments. Cinder and hot metal cars. Furnace Bells and Hoppers. Rolling Mill castings. Special attention paid to quick repair work and work governed by Engineers' specifications.

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BLOWERS, FANS, DRYERS, ETC.

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Condensers

M. T. DAVIDSON CO.

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New York, 15[illegible]
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High grade economical Pumps for all services. Surface and Jet Condensers.

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Wood Pulp and Paper Machinery

HOLYOKE MACHINE COMPANY

HOLYOKE, MASS.
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Water Wheels with Connections and Complete Power Transmission, Water Wheel Governors, Gearing, Wood Pulp and Paper Machinery, Pumps, Hydraulic Presses. Special Machinery to order.

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Paper Mill Machinery

J. & W. JOLLY, Inc.

HOLYOKE, MASS.

McCormick Holyoke Turbines designed to suit Mill or Hydro-Electric Work. Paper Mill Machinery, Shafting, Gearing, Pulleys and Freight Elevators.

See page 298 of Condensed Catalogues of Mechanical Equipment, 1913 Volume

Vacuum Pumps

LAMMERT & MANN

215-221 N. Wood St., CHICAGO, ILL.

Engineers and Machinists.
Manufacturers of Rotary Vacuum Pumps for highest dry vacuum, Lead Pumps, Rotary Blowers, etc.

ELECTRICAL APPARATUS, ENGINEERING MISCELLANY

Aluminum

ALUMINUM COMPANY OF AMERICA

PITTSBURGH, PA.

Aluminum Ingot, Sheet, Rod, Wire, Cable, Tubing and other forms.

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ELECTRIC WATER STERILIZER CO.

SCOTTDALE, PA.

Manufacturers of Electrical and Mechanical Water Purifying Machinery. Our Electric Water Sterilizing Machine is both economical in consumption of electric current and so simple that any one of average intelligence can take care of it. Guaranteed to deliver pure water. Capacities of stock machines from 40 to 1000 gallons per hour.

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UNION DRAWN STEEL CO.

BEAVER FALLS, PA.

Makers of Bright Cold Finished Bessemer, Open Hearth Crucible and Alloy Steels, in Rounds, Flats, Squares, Hexagons and Special Shapes.

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Dynamos
Motors
Transformers
Instruments

WAGNER ELECTRIC MANUFACTURING COMPANY

ST. LOUIS, MO.

Single-Phase Motors. Polyphase Motors. Transformers, Power and Pole Type. Instruments, a complete line. A. C. Generators. Converters for charging vehicle batteries from A. C. Rectifiers for charging small storage batteries from A. C. Train Lighting (Electric) Equipments. Automobile Self Starters (Electric), etc.

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Mesta Machine Co.
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Air Brakes, Compressors, Filters, etc.
(See Brakes, Compressors, Filters, etc., Air)

Air-Jet Lifts
Schutte & Koerting Co.

Air Lift Pumping Systems
* Ingersoll-Rand Co.

Air Tanks and Cylinders
(See Receivers, Air)

Air Washers
General Condenser Co.

Alternators
(See Generators, Electric)

Ammeters, Voltmeters
(See Electrical Instruments)

Ammonia Condensers, Fittings, etc.
(See Condensers, Fittings, etc., Ammonia)

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* Hooven, Owens, Rentschler Co.

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(See Lamps, Arc)

Arches, Ignition (Flat Suspended)
Green Engineering Co.

Ash Handling Systems, Pneumatic
* Green Engineering Co.

Augers, Power Coal
Fairmont Mining Mach. Co.

Balanced Main Valves
(See Valves, Balanced Distribution)

Barometers
* Tagliabue Mfg. Co., C. J.

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(See Bearings, Ball)

Balls, Brass and Bronze
* Auburn Ball Bearing Co.

Balls, Steel
* Auburn Ball Bearing Co.

Barrels, Tumbling
Royersford Foundry & Machine Co.

Bearings, Ball
* Auburn Ball Bearing Co.

Bearings, Roller
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Bearings, Self-Oiling
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Doehler Die-Casting Co.
* Falls Clutch & Machinery Co.
Franklin Manufacturing Co.
Jeffrey Manufacturing Co.

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* Auburn Ball Bearing Co.

Belt Dressing
Schieren Co., Chas. A.
* Texas Co.

Belt Lacing
Schieren Co., Chas. A.
Williams & Sons, I. B.

Belt Lacing, Steel
Bristol Co.

Belt Tighteners
* Brown Co., A. & F.

Belting, Chain
(See Chains and Chain Links)

Belting, Conveyor
* Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.

Belting, Rubber
* Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.

Belting, Leather
Schieren Co., Chas. A.
Williams & Sons, I. B.

Belting, Textile
* Goodrich Co., B. F.

Bending Machines, Hydraulic
* Wood & Co., R. D.

Blocks, Tackle
* Clyde Iron Works
* Hunt Co., Inc., C. W.
* Roebling's Sons Co., John A.

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De Laval Steam Turbine Co.
* General Electric Co.

Blowers, Fan
De Laval Steam Turbine Co.
Green Fuel Economizer Co.

Blowers, Rotary
Schutte & Koerting Co.

Blowers, Soot
Simonds & Co., G. L.

Blowers, Steam
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Boiler Coverings, Furnaces, Tube Cleaners, Tubes, etc.
(See Coverings, Furnaces, Tube Cleaners, Tubes, etc., Boiler)

Boilers, Heating
* Keeler Co., E.
* Smith Co., H. B.

Boilers, Locomotive
* Clyde Iron Works

Boilers, Marine
Babcock & Wilcox Co.
* Keeler Co., E.

Boilers, Tubular
* Clyde Iron Works
* Keeler Co., E.

Boilers, Water Tube
Babcock & Wilcox Co.
Heine Safety Boiler Co.
* Keeler Co., E.

Boring and Drilling Machines
Manning, Maxwell & Moore, Inc.

Brass-Working Machine Tools
(See Tools, Brass-working Machine)

Brick, Fire
* Betson Plastic Fire Brick Co.

Buckets, Elevator
Jeffrey Manufacturing Co.

Buckets, Grab
* Clyde Iron Works
* Hunt Co., Inc., C. W.
Jeffrey Manufacturing Co.
Orton & Steinbrenner Co.

Buckets, Self-Dumping
* Clyde Iron Works
* Hunt Co., Inc., C. W.
Orton & Steinbrenner Co.

Bulldozers
* Wood & Co., R. D.

Burners, Oil
Schutte & Koerting Co.

Cable, Wire
(See Rope, Wire)

Cable Railways
(See Railways, Cable)

Cableways, Wire
(See Tramways, Wire Rope)

Cables, Electrical
(See Wire and Cables, Electrical)

Cam Cutting Machines
Garvin Machine Co.

Car Hauls, Cable and Chain
Fairmont Mining Mach. Co.

Carriers and Elevators, Freight, Continuous
Jeffrey Manufacturing Co.
Mathews Gravity Carrier Co.

Cars, Dump
* Hunt Co., Inc., C. W.
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Cars, Motor
* Hunt Co., Inc., C. W.

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Franklin Manufacturing Co.
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Builders Iron Foundry
* Falls Clutch & Machinery Co.
Fairmont Mining Mach. Co.
* Hooven, Owens, Rentschler Co.
* Lunkenheimer Co.
Royersford Foundry & Machine Co.
* Wheeler Condenser & Engineering Co.
* Wood & Co., R. D.

Castings, Semi-Steel
Builders Iron Foundry
Fairmont Mining Mach. Co.
* Hooven, Owens, Rentschler Co.
* Lunkenheimer Co.
* Wood & Co., R. D.

Castings, Steel
Mesta Machine Co.

Cement, Belt
Schieren Co., Chas. A.

Cement, Fire Brick
* Betson Plastic Fire Brick Co.

Centrifugal Apparatus
De Laval Steam Turbine Co.

Centrifugal Pumps
(See Pumps, Centrifugal)

Chain Grate Stokers
(See Stokers, Chain Grate)

Chains and Chain Links
Jeffrey Manufacturing Co.

Channeling Machines, Mine and Quarry
Ingersoll-Rand Co.

Charging Machines, Furnace
* Alliance Machine Co.

Chimneys, Steel
(See Stacks, Steel)

Chucking Machines
Garvin Machine Co.
* Jones & Lamson Machine Co.

Chutes
Fairmont Mining Mach. Co.
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.

Chutes, Gravity Spiral
Mathews Gravity Carrier Co.

Circulators, Feed Water
Schutte & Koerting Co.

Circulators, Steam Heating
Schutte & Koerting Co.

Clamps, Pipe-Joint
Yarnall-Waring Co.

Clamps, Wire Rope
(See Wire Rope Fastenings)

Clutch Leathers
(See Leathers, Automobile)

Clutches, Friction
* Brown Co., A. & F.
Falls Clutch & Machinery Co.
Farrell Foundry & Machine Co.
Jeffrey Mfg. Co.
* Moore & White Co.

Coal and Ash Handling Machinery
Fairmont Mining Mach. Co.
* Green Engineering Co.
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.

Coal Crushers
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
Orton & Steinbrenner Co.

Coal Mine Equipments and Supplies
Fairmont Mining Mach. Co.
Jeffrey Mfg. Co.

Coal Mining Machinery
Ingersoll-Rand Co.
Jeffrey Mfg. Co.

Coaling Stations, Locomotive
Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.

Cocks, Air and Gage
Ashton Valve Co.
* Jenkins Bros.
* Lunkenheimer Co.

Cocks, Three-way and Four-way
Lunkenheimer Co.

Coils, Pipe
National Pipe Bending Co.

Coke Oven Machinery
* Alliance Machine Co.

Cold Storage Plants
De La Vergne Machine Co.

Combustion Recorders
Simonds & Co., G. L.

Compressors, Air
De Laval Steam Turbine Co.
* Devine Co., J. P.
* General Electric Co.
* Goulds Manufacturing Co.
* Hooven, Owens, Rentschler Co.
* Ingersoll-Rand Co.
Mesta Machine Co.
* Nordberg Mfg. Co.

Compressors, Air, Centrifugal
De Laval Steam Turbine Co.

Compressors, Air, Compound
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.

Compressors, Gas
De Laval Steam Turbine Co.
Hooven, Owens, Rentschler Co.
Ingersoll-Rand Co.
Mesta Machine Co.
* Nordberg Mfg. Co.

Condensation Pumps with Automatic Receivers
(See Pumps, Condensation with Automatic Receivers)

Condensers
* Devine Co., J. P.
* Nordberg Mfg. Co.
* Wheeler Condenser & Engineering Co.

Condensers, Ammonia
De La Vergne Machine Co.

Condensers, Barometric
Mesta Machine Co.
* Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.

Condensers, Jet
General Condenser Co.
Schutte & Koerting Co.
Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.

Condensers, Surface
General Condenser Co.
* Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.

Controllers, Automatic, for Temperature or for Pressure
(See Regulators)

Controllers, Electric
* General Electric Co.

Converters, Synchronous
* General Electric Co.

Conveying Machinery
Fairmont Mining Mach. Co.
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
Mathews Gravity Carrier Co.

Conveyors, Belt
Fairmont Mining Mach. Co.
Jeffrey Manufacturing Co.

Conveyors, Bucket, Pan or Apron
Fairmont Mining Mach. Co.
* Hunt Co., Inc., C. W.
Jeffrey Manufacturing Co.

Conveyors, Gravity
Mathews Gravity Carrier Co.

Conveyors, Gravity Roller
Mathews Gravity Carrier Co.

Conveyors, Screw
Jeffrey Manufacturing Co.

Cooling Ponds, Spray
Schutte & Koerting Co.

Cooling Towers
* Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.

Copper, Drawn
* Roebling's Sons Co., John A.

Copper Wire and Cables
(See Wires and Cables, Electrical)

Copper Converting Machinery
* Alliance Machine Co.

Catalogue data of firms marked * appears in the A. S. M. E. Condensed Catalogues of Mechanical Equipment, 1914 Volume.

Catalogue data of firms marked * appears in the A. S. M. E. Condensed Catalogues of Mechanical Equipment, 1914 Volume.

Heaters, Feed Water (Closed)
National Pipe Bending Co.
Schutte & Koerting Co.
* Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.

Heaters, Metering
Harrison Safety Boiler Works

Heaters and Purifiers, Feed Water (Open)
Harrison Safety Boiler Works
National Pipe Bending Co.

Heating Boilers
(See Boilers, Heating)

Heating and Ventilating Apparatus
Green Fuel Economizer Co.
* Smith Co., H. B.

Hoisting and Conveying Machinery
Box & Co., Alfred
* Clyde Iron Works
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
Orton & Steinbrenner Co.

Hoists, Air
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.

Hoists, Belt
Clyde Iron Works

Hoists, Electric
* Alliance Machine Co.
Box & Co., Alfred
* Clyde Iron Works
* General Electric Co.
* Hunt Co., Inc., C. W.
* Nordberg Mfg. Co.
Orton & Steinbrenner Co.

Hoists, Hand
* Clyde Iron Works

Hoists, Skip
* Hunt Co., Inc., C. W.

Hoists, Steam
* Clyde Iron Works
Hunt Co., Inc., C. W.
Mesta Machine Co.
Morris Machine Works
Nordberg Mfg. Co.
Orton & Steinbrenner Co.

Holders, Gas
* Wood & Co., R. D.

Hose, Air
Goodrich Co., B. F.
* Ingersoll-Rand Co.
Manhattan Rubber Mfg. Co.

Hose, Linen
Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.

Hose, Oil
Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.

Hose, Rubber
Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.

Hose, Steam
Goodrich Co., B. F.
Ingersoll-Rand Co.
Manhattan Rubber Mfg. Co.

Hose, Suction
* Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.

Hose Attachments (Couplings, Bands, Holders, Clamps, etc.)
* Goodrich Co., B. F.
* Ingersoll-Rand Co.
Manhattan Rubber Mfg. Co.

Hydrants, Fire
* Wood & Co., R. D.

Hydraulic Jacks, Rams, Presses, Turbines, etc.
(See Jacks, Rams, Presses, Turbines, etc., Hydraulic)

Hydraulic Machinery
* Alliance Machine Co.
* Wood & Co., R. D.

Hydrokineters
Schutte & Koerting Co.

Hydrometers
* Tagliabue Mfg. Co., C. J.

Hygrometers
Brown Instrument Co.
Tagliabue Mfg. Co., C. J.

I-Beam Trolleys
(See Trolleys, I-Beam)

Ice and Refrigeration Machinery
* De La Vergne Machine Co.

Impregnating Apparatus
* Devine Co., J. P.

Incandescent Lamps
(See Lamps, Incandescent)

Indicator Posts
* Wood & Co., R. D.

Indicators, Engine
Manning, Maxwell & Moore Inc.

Indicators, Smoke
Simonds & Co., G. L.

Indicators, Speed
Brown Instrument Co.
* Veeder Manufacturing Co.
Weston Electrical Instrument Co.

Industrial Railway Equipment
* Hunt Co., Inc., C. W.

Injectors
Manning, Maxwell & Moore Inc.
* Lunkenheimer Co.
Schutte & Koerting Co.

Jigs and Fixtures
Cowdrey Machine Works, C. H.

Joints, Expansion
* Lunkenheimer Co.
Power Specialty Co.
Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.

Joints, Rail
Rail Joint Co.

Jolt Ramming Machines
(See Rammers, Foundry)

Lamps, Incandescent and Arc
* General Electric Co.

Land-Clearing Machinery
* Clyde Iron Works

Lathes
Builders Iron Foundry
Garvin Machine Co.
* Jones & Lamson Machine Co.
Manning, Maxwell & Moore, Inc.
* Warner & Swasey Co.

Lathes, Automatic
* Jones & Lamson Machine Co.

Lathes, Brass
Garvin Machine Co.
* Warner & Swasey Co.

Lathes, Chucking
Jones & Lamson Machine Co.

Lathes, Turret
Garvin Machine Co.
Jones & Lamson Machine Co.
Warner & Swasey Co.

Leather Belting, Packing, etc.
(See Belting, Packing, etc., Leather)

Leathers, Automobile
Schieren Co., Chas. A.

Leathers, Pump
Schieren Co., Chas.
Williams & Sons, I. B.

Lightning Arresters
* General Electric Co.

Linings, Furnace
Betson Plastic Fire Brick Co.

Loaders, Box Car
Fairmont Mining Machine Co.

Locomotives, Compressed Air
Ingersoll-Rand Co.

Locomotive, Electric
General Electric Co.
Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.

Logging Machinery
Clyde Iron Works

Lubricants
Royersford Foundry & Machine Co.
* Texas Co.

Lubricators
Lunkenheimer Co.

Lubricators, Force-Feed
Lunkenheimer Co.

Lubricators, Hydrostatic
* Lunkenheimer Co.

Machinery
(Is classified under the headings descriptive of character thereof)

Machinery Dealers
Garvin Machine Co.
Manning, Maxwell & Moore Inc.

Machinists and Engineers
* Brown Co., A. & F.
Builders Iron Foundry
Cowdrey Machine Works, C. H.
* Wood & Co., R. D.

Mechanical Draft Apparatus
Green Fuel Economizer Co.

Mechanical Stokers
(See Stokers)

Metal Work, Plate
Heine Safety Boiler Co.
* Keeler Co., E.
* Wood & Co., R. D.

Meters, Air, Steam and Gas
Builders Iron Foundry
* General Electric Co.

Meters, Electric
Bristol Co.
Brown Instrument Co.
* General Electric Co.

Meters, V-Notch
Harrison Safety Boiler Works
Yarnall-Waring Co.

Meters, Venturi
Builders Iron Foundry
* National Meter Co.

Meters, Water
Builders Iron Foundry
* General Electric Co.
Harrison Safety Boiler Works
* National Meter Co.
Yarnall-Waring Co.

Milling Attachments
Garvin Machine Co.

Milling Machines, Hand
Garvin Machine Co.

Milling Machines, Horizontal
Garvin Machine Co.

Milling Machines, Plain
Garvin Machine Co.
Warner & Swasey Co.

Milling Machines, Universal
Garvin Machine Co.

Milling Machines, Vertical
Garvin Machine Co.

Mills, Blooming and Slabbing
Mesta Machine Co.

Mills, Sheet and Plate
Mesta Machine Co.

Mills, Structural, Rail and Bar
Mesta Machine Co.

Mills, Sugar Cane
* Fulton Iron Works
Mesta Machine Co.

Monorail Systems
(See Tramrail Systems, Overhead)

Motors, Compressed Air
* Ingersoll-Rand Co.

Motors, Electric
General Electric Co.

Nozzles, Blast
Schutte & Koerting Co.

Nozzles, Sand and Air
Ingersoll-Rand Co.
Lunkenheimer Co.

Nozzles, Spray
Schutte & Koerting Co.

Odometers
Veeder Manufacturing Co.

Oils, Fuel
* Texas Co.

Oils, Lubricating
Texas Co.

Oil Burning Systems
Schutte & Koerting Co.

Oil Testing Instruments
* Tagliabue Mfg. Co., C. J.

Oil and Grease Cups
* Lunkenheimer Co.

Oiling Devices
* Lunkenheimer Co.

Oiling Systems
Lunkenheimer Co.

Oil Burners, Engines, Filters, Pumps, Separators, etc.
(See Burners, Engines, Filters, Pumps, Separators, etc., Oil)

Ore Handling Machinery
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.

Packing, Hydraulic
* Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.
Power Specialty Co.
Schieren Co., Chas. A.
Williams & Sons, I. B.

Packing, Leather
Schieren Co., Chas. A.
Williams & Sons, I. B.

Packing, Metallic
Power Specialty Co.

Packing, Rod (Piston and Valve)
* Goodrich Co., B. F.
* Jenkins Bros.
Manhattan Rubber Mfg. Co.
Power Specialty Co.

Packing, Rubber
* Goodrich Co., B. F.
* Jenkins Bros.
Manhattan Rubber Mfg. Co.

Packing, Sheet
* Goodrich Co., B. F.
* Jenkins Bros.
Manhattan Rubber Mfg. Co.

Pans, Vacuum
* Devine Co., J. P.
* Wheeler Condenser & Engineering Co.

Paper Machinery
* Moore & White Co.

Petroleum Products
* Texas Co.

Pickling Machines
Mesta Machine Co.

Pile Drivers
* Clyde Iron Works

Pile Drivers, Sheet
* Ingersoll-Rand Co.

Pinions, Rolling Mill
Mesta Machine Co.

Pinions, Rawhide
New Process Gear Corp.

Pipe, Cast Iron
Builders Iron Foundry

Pipe, Riveted Steel
* Keeler Co., E.

Pipe Bends and Pipe Bending
National Pipe Bending Co.

Pipe Coils, Covering, Cutters, Fittings, Joints, etc.
(See Coils, Covering, Cutters, Fittings, Joints, etc., Pipe)

Pipe Joint Clamps
(See Clamps, Pipe Joint)

Piston Valves
(See Valves, Piston)

Planers, Metal
Manning, Maxwell & Moore Inc.

Plate Metal Work
(See Metal Work, Plate)

Pneumatic Pumping Systems
(See Air Lift Pumping Systems)

Pneumatic Tools
* Ingersoll-Rand Co.

Polishing Machinery
Builders Iron Foundry
Royersford Foundry & Machine Co.

Poppet Valve Engines
(See Engines, Poppet Valve)

Power Transmission Machinery
Brown Co., A. & F.
Falls Clutch & Machinery Co.
Farrel Foundry & Machine Co.
Jeffrey Mfg. Co.
Moore & White Co.
Royersford Foundry & Machine Co.

Presses, Hydraulic
Alliance Machine Co.
Falls Clutch & Machinery Co.
Manning, Maxwell & Moore Inc.
Mesta Machine Co.
Wood & Co., R. D.

Presses, Forging (Steam-Hydraulic)
Mesta Machine Co.
Wood & Co., R. D.

Presses, Punching and Trimming
Royersford Foundry & Machine Co.

Pressure Regulators
(See Regulators, Pressure)

Producers, Gas
* De La Vergne Machine Co.
* Wood & Co., R. D.

Profiling Machines
Garvin Machine Co.

Propellers
* Morris Machine Works

Catalogue data of firms marked * appears in the A. S. M. E. Condensed Catalogues of Mechanical Equipment, 1914 Volume.

Pulleys, Iron
* Brown Co., A. & F.
* Falls Clutch & Machinery Co.
Jeffrey Mfg. Co.

Pulverizers
Brown Co., A. & F.
Jeffrey Mfg. Co.

Pump Governors, Valves, etc.
(See Governors, Valves, Pump)

Pumping Engines
(See Engines, Pumping)

Pumping Machinery
De Laval Steam Turbine Co.
* Goulds Manufacturing Co.
* Morris Co., I. P.
* Morris Machine Works
Providence Engineering Works
* Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.
* Wood & Co., R. D.

Pumps, Air
General Condenser Co.
* Goulds Manufacturing Co.
* Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.

Pumps, Boiler Feed
De Laval Steam Turbine Co.
Goulds Manufacturing Co.
Providence Engineering Works
* Wheeler Mfg. Co., C. H.

Pumps, Centrifugal
De Laval Steam Turbine Co.
* Goulds Manufacturing Co.
* Morris Co., I. P.
* Morris Machine Works
Providence Engineering Works
* Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.
* Wood & Co., R. D.

Pumps, Condensation, with Automatic Receivers
* Wheeler Mfg. Co., C. H.

Pumps, Deep Well
* Goulds Manufacturing Co.
* Ingersoll-Rand Co.
* Morris Machine Works

Pumps, Dredging
De Laval Steam Turbine Co.
* Morris Machine Works
* Wood & Co., R. D.

Pumps, Dry Vacuum
(See Pumps, Vacuum)

Pumps, Electric
De Laval Steam Turbine Co.
Fairmont Mining Mach. Co.
* Goulds Manufacturing Co.
* Morris Machine Works
* Wood & Co., R. D.

Pumps, Hand
* Goulds Manufacturing Co.

Pumps, Hydraulic Pressure
* Goulds Manufacturing Co.
* Morris Machine Works
* Wood & Co., R. D.

Pumps, Oil
* Goulds Manufacturing Co.
* Lunkenheimer Co.
* Wood & Co., R. D.

Pumps, Oil, Force-Feed
* Lunkenheimer Co.

Pumps, Power
Fairmont Mining Mach. Co.
* Goulds Manufacturing Co.
* Wood & Co., R. D.

Pumps, Rotary
* Goulds Manufacturing Co.

Pumps, Steam
Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.

Pumps, Sump
De Laval Steam Turbine Co.
Fairmont Mining Mach. Co.
* Goulds Manufacturing Co.
* Morris Machine Works
* Wood & Co., R. D.

Pumps, Tank
* Goulds Manufacturing Co.
* Wheeler Mfg. Co., C. H.
Wood & Co., R. D.

Pumps, Turbine
De Laval Steam Turbine Co.
* General Electric Co.
* Morris Machine Works
* Wood & Co., R. D.

Pumps, Vacuum
* Devine Co., J. P.
General Condenser Co.
* Goulds Manufacturing Co.
* Nordberg Mfg. Co.
* Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.

Punches, Hydraulic
Alliance Machine Co.
* Wood & Co., R. D.

Punches, Power
Royersford Foundry & Machine Co.

Punches, Multiple
* Wood & Co., R. D.

Punches and Dies
Royersford Foundry & Machine Co.

Punching and Shearing Machines
Alliance Machine Co.
Royersford Foundry & Machine Co.
* Wood & Co., R. D.

Purifying and Softening Systems, Water
Harrison Safety Boiler Works

Pyrometers, Electric
Bristol Co.
Brown Instrument Co.
Industrial Instrument Co.
* Tagliabue Mfg. Co., C. J.

Pyrometers, Mercurial
Ashton Valve Co.
Brown Instrument Co.
Industrial Instrument Co.
* Tagliabue Mfg. Co., C. J.

Pyrometers, Radiation
Brown Instrument Co.

Quarry Machinery
* Ingersoll-Rand Co.

Racks, Cut
James Mfg. Co., D. O.

Radiators, Indirect
* Smith Co., H. B.

Radiators, Steam
* Smith Co., H. B.

Rail Joints
(See Joints, Rail)

Railways for Industrial Purposes
* Hunt Co., Inc., C. W.

Railways, Cable and Automatic
Fairmont Mining Mach. Co.
* Hunt Co., Inc., C. W.

Rammers, Foundry
* Ingersoll-Rand Co.

Rams, Hydraulic
* Goulds Manufacturing Co.

Receivers, Air
* Devine Co., J. P.
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.

Recording Instruments
Ashton Valve Co.
Bristol Co.
Brown Instrument Co.
Builders Iron Foundry
* General Electric Co.
Harrison Safety Boiler Works
Industrial Instrument Co.
Yarnall-Waring Co.

Refrigerating Machinery
* De La Vergne Machine Co.

Refuse Destructors
(See Destructors, Refuse)

Regulators, Blower
Davis Regulator Co., G. M.
* Tagliabue Mfg. Co., C. J.

Regulators, Damper
Davis Regulator Co., G. M.

Regulators, Electric
* General Electric Co.

Regulators, Flow (Steam)
Davis Regulator Co., G. M.
Schutte & Koerting Co.

Regulators, Pressure
Davis Regulator Co., G. M.
* Tagliabue Mfg. Co., C. J.

Regulators, Pump
(See Governors, Pump)

Regulators, Temperature
* Tagliabue Mfg. Co., C. J.

Reseating Machines
Lagonda Manufacturing Co.

Retarders, Mine and Railroad Car
Fairmont Mining Mach. Co.

Revolution Counters
(See Counters, Revolution)

Riveters, Hydraulic
* Alliance Machine Co.
* Wood & Co., R. D.

Riveters, Pneumatic
* Ingersoll-Rand Co.

Roller Bearings
(See Bearings, Roller)

Rolling Mill Machinery
* Alliance Machine Co.
Mesta Machine Co.

Rolls, Forging
Mesta Machine Co.

Rolls, Sand, Chilled and Steel
Farrel Foundry & Machine Co.
Mesta Machine Co.

Rolls, Rubber
* Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.

Roofing
* Texas Co.

Rope Drives
* Brown Co., A. & F.
* Falls Clutch & Machinery Co.
Jeffrey Mfg. Co.

Rope, Hoisting
* Clyde Iron Works
* Hunt Co., Inc., C. W.
Roebling's Sons Co., John A.

Rope, Transmission
* Hunt Co., Inc., C. W.
Roebling's Sons Co., John A.

Rope, Wire
* Clyde Iron Works
Roebling's Sons Co., John A.

Rubber Goods, Mechanical
* Goodrich Co., B. F.
* Jenkins Bros.
Manhattan Rubber Mfg. Co.

Sand Blast Apparatus
* De La Vergne Machine Co.
* Ingersoll-Rand Co.
Lunkenheimer Co.

Screens, Revolving
Fairmont Mining Mach. Co.
Jeffrey Manufacturing Co.

Screens, Shaking
Fairmont Mining Mach. Co.
Jeffrey Manufacturing Co.

Screw Cutting Dies
(See Dies, Screw and Thread Cutting)

Screw Machines, Hand
Garvin Machine Co.
* Jones & Lamson Mach. Co.
* Warner & Swasey Co.

Screws, Safety Set
Bristol Co.

Separators, Air
General Condenser Co.

Separators, Ammonia
* De La Vergne Machine Co.

Separators, Oil
* De La Vergne Machine Co.
General Condenser Co.
Harrison Safety Boiler Works
National Pipe Bending Co.
* Wheeler Condenser & Engineering Co.

Separators, Steam
General Condenser Co.
Harrison Safety Boiler Works
National Pipe Bending Co.

Shafting
* Brown Co., A. & F.
Cumberland Steel Co.

Shears, Hydraulic
* Alliance Machine Co.
Mesta Machine Co.
* Wood & Co., R. D.

Shears, Lever
Mesta Machine Co.

Shears, Plate
Alliance Machine Co.
Mesta Machine Co.
* Wood & Co., R. D.

Sheaves, Rope
* Brown Co., A. & F.
* Clyde Iron Works
Fairmont Mining Mach. Co.
* Falls Clutch & Machinery Co.
Jeffrey Mfg. Co.

Sheet and Tin-Plate Machinery
Mesta Machine Co.

Sirens
(See Whistles, Steam)

Skiving Machines
Fortuna Machine Co.

Slide Valves
(See Valves, Slide)

Sluice Gates
(See Gates, Sluice)

Smoke Indicators
(See Indicators, Smoke)

Smoke Stacks and Flues
(See Stacks, Steel)

Special Machinery
* Brown Co., A. & F.
Builders Iron Foundry
Cowdrey Machine Works, C. H.
Farrel Foundry & Machine Co.
Garvin Machine Co.
Mesta Machine Co.
* Morris Co., I. P.
Providence Engineering Works
* Wood & Co., R. D.

Speed Transmissions, Variable
* Moore & White Co.

Speed Reducing Transmissions
De Laval Steam Turbine Co.
James Mfg. Co., D. O.

Spirals, Gravity Roller
Mathews Gravity Carrier Co.

Spray Nozzles
(See Nozzles, Spray)

Sprockets
Jeffrey Manufacturing Co.

Sockets, Wire Rope
(See Wire Rope Fastenings)

Soot Blowing Systems
Simonds & Co., G. L.

Stacks, Steel
Heine Safety Boiler Co.
* Keeler Co., E.

Stamps, Steam
* Nordberg Manufacturing Co.

Steam Engines, Separators, Shovels, Superheaters, Traps, Turbines, etc.
(See Engines, Separators, Shovels, Superheaters, Traps, Turbines, etc., Steam)

Steam Specialties
Davis Regulator Co., G. M.
Lagonda Mfg. Co.
* Lunkenheimer Co.
Manning, Maxwell & Moore, Inc.

Steel, Cold Rolled
Cumberland Steel Co.

Steel Plate Construction
Heine Safety Boiler Co.
* Keeler Co., E.
* Wood & Co., R. D.

Steel Ties, Tipples, etc.
(See Ties, Tipples, etc., Steel)

Stokers
American Engineering Co.
Babcock & Wilcox Co.
* Green Engineering Co.
* Murphy Iron Works

Stokers, Chain Grate
Babcock & Wilcox Co.
Green Engineering Co.

Stokers, Inclined Grate
* Murphy Iron Works

Stokers, Underfeed
American Engineering Co.

Strainers, Water
Lagonda Manufacturing Co.
Schutte & Koerting Co.

Sugar Machinery
* Hooven, Owens, Rentschler Co.
* Wood & Co., R. D.

Superheaters, Air
Power Specialty Co.

Superheaters, Steam
Babcock & Wilcox Co.
Heine Safety Boiler Co.
Power Specialty Co.

Switchboards
* General Electric Co.

Switches, Electric
* General Electric Co.

Switches and Frogs, Railroad
Rail Joint Co.

Synchronous Converters
(See Converters, Synchronous)

Syphons (Steam-Jet)
Schutte & Koerting Co.

Tachometers
Brown Instrument Co.
Industrial Instrument Co.
* Veeder Mfg. Co.
Weston Electrical Instrument Co.

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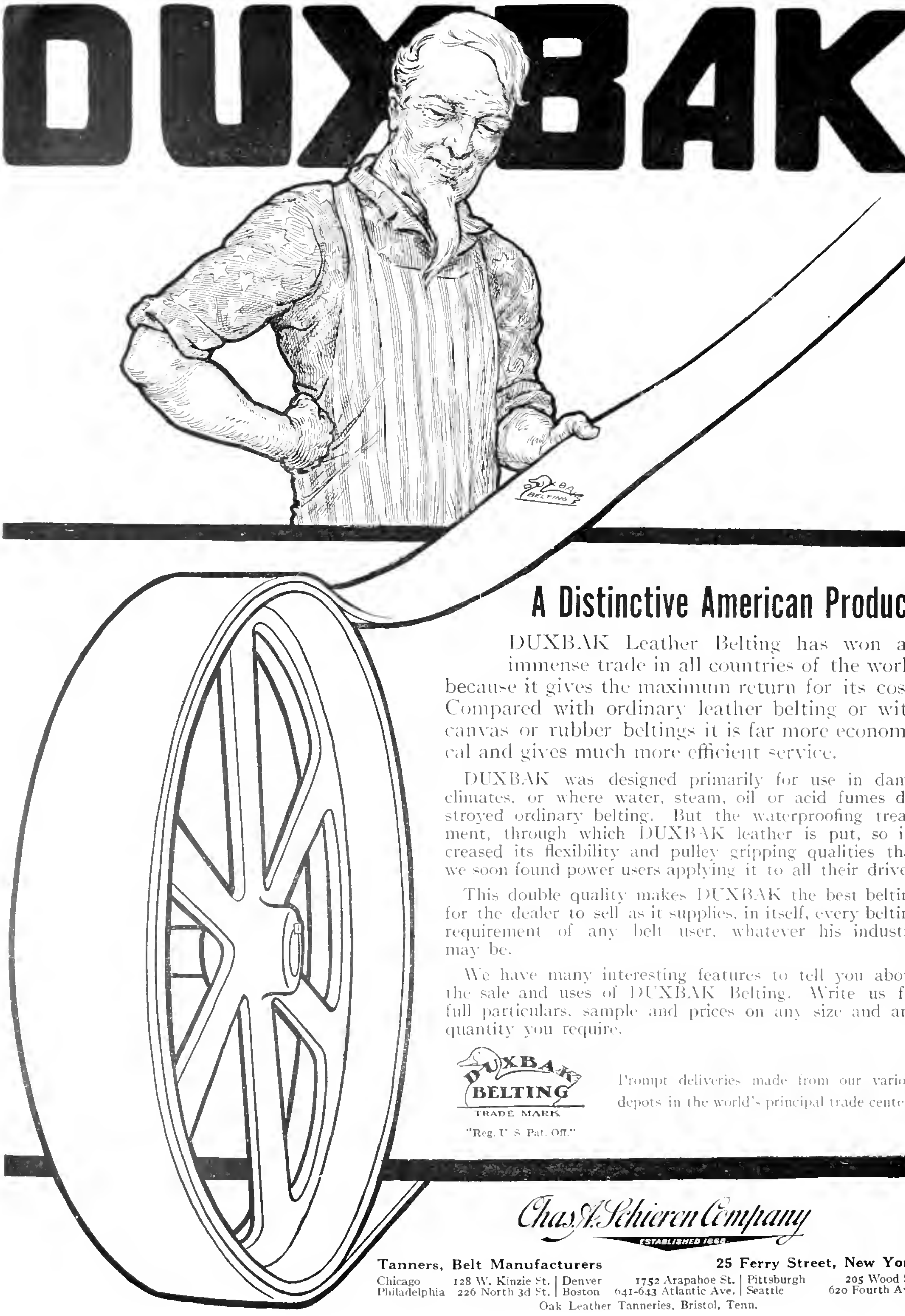
Catalogue data of firms marked * appears in the A. S. M. E. Condensed Catalogues of Mechanical Equipment, 1914 Volume.

DUXBAK



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ALPHABETICAL LIST OF ADVERTISERS

See Pages 45-49 for Classified List of Mechanical Equipment

Catalogue data of firms marked * appears in the A.S.M.E. Condensed Catalogues of Mechanical Equipment, 1914 Volume

THE JOURNAL
OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

29 West 39th Street, New York

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

INCLUDING THE TRANSACTIONS OF THE SOCIETY

DECEMBER · 1914

ANNUAL MEETING, NEW YORK CITY, DECEMBER 1-4

WHY ATTEND THE ANNUAL MEETING

The program for the 35th Annual Meeting (see Page IV) includes a number of subjects of particular interest to the various industries of the country—*Boiler Code*, *Building Construction*, *Management*, *Grinding*, *Steam Locomotives*, *all-day session on Engineering in the Administration of a City*, *Iron and Steel*, *Air Compressors*, *etc.*—and on December 1-4 the Headquarters of the Society will be the rendezvous of the mechanical engineering profession.

The following analysis shows the various divisions of engineering work represented by our membership:

Executives: President, Vice-President, Treasurer. Director, Member of Firm, General Manager	1202
Consulting Engineers, Contracting and Constructing Engineers	566
General Superintendent, Superintendent, Assistant Superintendent, Mechanical Superintendent	615
Chief Engineers, Assistant Chief Engineers	361
Mechanical Engineers, Engineers, Assistant Engineers	1900
Chief Draftsmen, Assistant Chief Draftsmen, Designing Engineers, Estimators	326
Managers, Assistant Managers, Sales Managers, Sales Engineers	594
Other classifications	440
Total membership, November 1, 1914	6004

No member can fail to profit by the opportunity afforded for making new acquaintances and renewing old friendships among this great body of engineers, and all should take advantage of the excellent opportunity afforded to extend the hospitality of the Society to professional associates and acquaintances.

CHANGE OF ADDRESS

Members who have changed their addresses during the past year and who have not notified the Society are requested to fill out the blank below as indicated and return it to the Society. These corrections are for use in the Year Book for 1915, and should be received by December 15 to insure their appearance.

(Cut off along this line)

The American Society of Mechanical Engineers

29 West 39th Street, New York

ADDRESS BLANK

(Fill in every space below. Write distinctly. Typewriting preferred)

Underline the Mail Address

Name...

Title or Position...

Name of Firm...

Business Address...

....

Home Address...

....

....

A new Year Book is about to go to press. Please return this sheet not later than December 15, 1914

THE JOURNAL OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

(Including Transactions)

Volume 36 DECEMBER 1914 Number 12

CONTENTS

PUBLISHED MONTHLY BY

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

29 West Thirty-ninth Street, New York

Price 35 Cents a Copy, $3.00 a Year; to Members and Affiliates, 25 Cents a Copy, $2.00 a Year. Postage to Canada, 50 Cents Additional; to Foreign Countries $1.00 Additional

Entered as second-class matter, January 4, 1912, at the Postoffice, New York, N. Y., under the act of March 3, 1879

COMING MEETINGS OF THE SOCIETY

Annual Meeting, December 1–4. *New York City.* For program see p. IV.

December 8, *San Francisco, Cal.* Paper: A Novel Method of Handling Boilers to Prevent Corrosion and Scale, by Allen H. Babcock, Consulting Electrical Engineer, Southern Pacific Company.

December 9, *Boston, Mass.* Engineers Club. Paper: The Technology of Paper Making, by V. E. Nunez, expert with Arthur D. Little, Inc., Boston.

January 8, *Chicago, Ill.* Railroad meeting, with papers on Locomotive Superheaters and Stokers.

January 14, *Philadelphia, Pa.* Joint meeting with the Franklin Institute. Paper: Modern Steels and their Heat Treatment, by Robert R. Abbott.

THE JOURNAL OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
(Including Transactions)

Volume 36 December 1914 Number 12

THE ANNUAL MEETING

DECEMBER 1-4, 1914

THE feature of the professional sessions of the Annual Meeting will be the sessions on Thursday, December 3, relating to the work of the Engineer in Public Service. The session in the morning will be opened by the Hon. John Purroy Mitchel, Mayor of the City of New York, and papers will be presented by Henry Bruère, City Chamberlain of New York City and director of the National Bureau of Municipal Research; Morris L. Cooke, director of the Department of Public Works of Philadelphia; Edward Flad, consulting engineer, St. Louis; and C. E. Drayer, chairman of the Publicity Committee of the Cleveland Engineering Society. At the afternoon session papers will be presented by Frederick W. Ballard, Commissioner of Lighting of the Department of Public Utilities of Cleveland; George S. Webster, chief engineer of the Bureau of Surveys of Philadelphia; Clyde Lyndon King, assistant professor in Political Science of the University of Pennsylvania; and Sanford E. Thompson, consulting engineer, Newton Highlands, Mass.

These Public Service sessions have been arranged by the Public Relations Committee of the Society and will draw to the attention of engineers the opportunities for the application of their special training and knowledge to the better solution of the many important engineering problems that confront the large municipality.

In the sessions devoted to miscellaneous engineering subjects, it will be noted by reference to the program that several of the papers have been contributed by sub-committees of the Society, which emphasizes the work which the Society is doing in presenting authoritative contributions on different phases of a variety of engineering subjects. There are to be six professional sessions on the technical side of mechanical engineering, in which the variety of papers is so great that they are bound to appeal to the membership in one way or another. One of these sessions, as at recent meetings, will be devoted to a discussion of railroad subjects. The sub-committee on Railroads has prepared a report on Steam Locomotives of Today, upon which discussion has been invited from railroad men who have specialized on different aspects of the subject.

All of the papers listed in the program are now available for distribution and copies of any of them will be mailed free to members requesting them in advance.

On Wednesday morning at the business session the progress report of the Boiler Specifications Committee will come up for discussion. This report, which has been in preparation for the past three years, is one of the most important ever issued by the Society, and has required weeks of devoted labor on the part of the committee. During the past two months there have been almost constant conferences with engineers, manufacturers and professional organizations, and the report has been studied from every angle, with a view to establishing a standard that may form the basis for uniform and safe practice in the construction and operation of steam boilers throughout the country.

On Wednesday evening, the John Fritz Medal will be awarded to Prof. John E. Sweet, Honorary Member and Past-President of the Society, "for his achievements in machine design and for his pioneer work in applying sound engineering principles to the construction and development of the high-speed steam engine." To Professor Sweet more than to any other living man the formation of the Society is due, through his personal work in visiting engineers throughout the country and interesting them in the possibilities of a national organization for the advancement of mechanical engineering. The John Fritz Medal is awarded by the four national engineering societies. Following the presentation there will be addresses by Dr. James Douglas, Honorary Member and Past-President of the American Institute of Mining Engineers, and by Dr. S. W. Stratton, Director of the Bureau of Standards, on the Development of Engineering in the United States, Dr. Stratton speaking especially of the relation of the Bureau of Standards to such development.

On Thursday evening the chief social event of the meeting will take the form of a dinner dance. Covers

will be [illegible] the main ballroom of the Hotel Astor and there will be dancing between courses. A large attendance is expected.

The Ladies Committee is arranging for a reception and thé dansant to be held on Wednesday afternoon in the rooms of the Society, at which both members and guests will be welcomed.

The Excursion Committee has arranged as usual for visits of interest about the city, including manufacturing plants and power stations, so that those who so desire will be able to see as much of the important engineering features in this vicinity as time will permit.

PROGRAM

Tuesday Afternoon, December 1

Registration. Council Meeting at 4.00 p.m.

Tuesday Evening

OPENING SESSION, 8.30 P.M.

President's Address, THE HUMAN ELEMENT THE KEY TO ECONOMIC PROBLEMS, James Hartness

Report of Tellers of election of officers

Introduction of President-elect

Reception by the Society to the President, President-elect, ladies, members and guests in the rooms of the Society. Music and refreshments. Open to all members and guests.

Wednesday Morning, December 2

BUSINESS MEETING, 10.00 A.M.

Reports of the Council and Standing Committees. Amendment to C 45 of the Constitution. Progress Report of the Boiler Specifications Committee

PROFESSIONAL SESSION

FLOOR SURFACES IN FIREPROOF BUILDINGS, Sanford E. Thompson

(CONTRIBUTED BY THE SUB-COMMITTEE ON INDUSTRIAL BUILDING.)

REINFORCED-CONCRETE FACTORY BUILDINGS, F. W. Dean

(CONTRIBUTED BY THE SUB-COMMITTEE ON TEXTILES.)

Wednesday Afternoon

PROFESSIONAL SESSION, 2.00 P.M

MEASURING EFFICIENCY, H. L. Gantt

STANDARDIZATION IN THE FACTORY, C. B. Auel

(CONTRIBUTED BY THE SUB-COMMITTEE ON MACHINE SHOP PRACTICE.)

OPERATION OF GRINDING WHEELS IN MACHINE GRINDING, Geo. I. Alden

FRICTION LOSSES IN THE UNIVERSAL JOINT, P. F. Walker and W. J. Malcolmson

RAILROAD SESSION (SIMULTANEOUS), 2.00 P.M.

STEAM LOCOMOTIVES OF TODAY: Report of the Sub-Committee on Railroads

Wednesday Evening

JOHN FRITZ MEDAL AWARD, 8.30 P.M.

The John Fritz Medal will be awarded to Prof. John E. Sweet, Honorary Member and Past-President of the Society. Addresses by Dr. James Douglas, Honorary Member and Past-President of the American Institute of Mining Engineers and Dr. S. W. Stratton, Director of the Bureau of Standards.

Thursday, December 3

There will be an all-day Public Service Meeting on the subject of Engineering in the Administration of a City, with papers contributed by the Committee on Public Relations. The following is a tentative program:

PUBLIC SERVICE SESSION, 10.00 A.M.

OPENING REMARKS, Hon. John Purroy Mitchel, Mayor of the City of New York

THE FUTURE OF THE POLICE ARM FROM AN ENGINEERING STANDPOINT, Henry Bruère

SOME FACTORS IN MUNICIPAL ENGINEERING, Morris L. Cooke

THE NEW CHARTER FOR ST. LOUIS, Edward Flad

THE ENGINEER AND PUBLICITY, C. E. Drayer

SNOW REMOVAL: A Report of the Committee on Resolutions of the Snow Removal Conference held in Philadelphia, April 16 and 17, 1914

Thursday Afternoon

PUBLIC SERVICE SESSION (CONTINUED), 2.00 P.M.

THE DESIGN AND OPERATION OF THE CLEVELAND MUNICIPAL ELECTRIC LIGHT PLANT, Frederick W. Ballard

THE HANDLING OF SEWAGE SLUDGE, George S. Webster

TRAINING FOR THE MUNICIPAL SERVICE IN GERMANY, Clyde Lyndon King

A STUDY OF CLEANING FILTER SANDS WITH NO OPPORTUNITY FOR BONUS PAYMENTS, Sanford E. Thompson

PROFESSIONAL SESSION (SIMULTANEOUS), 2.00 P.M

FACTORS IN HARDENING TOOL STEEL, John A. Mathews and Howard J. Stagg, Jr.

(CONTRIBUTED BY THE SUB-COMMITTEE ON IRON AND STEEL.)

STANDARDIZATION OF CHILLED IRON CRANE WHEELS, F. K. Vial

(CONTRIBUTED BY THE SUB-COMMITTEE ON HOISTING AND CONVEYING.)

THE MECHANICAL ELIMINATION OF SEAMS IN STEEL PRODUCTS, NOTABLY STEEL RAILS, R. W. Hunt

CEMENT SESSION (SIMULTANEOUS), 2.00 P.M.

Informal gathering of those interested in the Manufacture of Cement, with paper on ELECTRIC DRIVE FOR ECONOMIC OPERATION AND DEVELOPMENT OF CEMENT MILLS, J. Benton Porter

STUDENT BRANCH CONFERENCE, 4.00 P.M.

A conference of the honorary chairmen of the Student Branches will be held with the Committee on Student Branches

Thursday Evening

DINNER DANCE, 7.00 P.M.

This is the main social event of the Annual Meeting and will be held in the grand ballroom of the Hotel Astor.

Friday Morning, December 4

PROFESSIONAL SESSION, 10.00 A.M.

A RATE-FLOW METER, H. C. Hayes

LABORATORY FOR TESTING AND INVESTIGATING LIQUID FLOW METERS OF LARGE CAPACITY, W. S. Giele

A NEW VOLUME REGULATOR FOR AIR COMPRESSORS, Ragnar Wikander

PHYSICAL LAWS OF METHANE GAS, P. F. Walker

THE CLINKERING OF COAL, Lionel S. Marks

DAMAGES FOR LOSS OF WATER POWER, F. W. Dean

Friday Afternoon

Council Meeting at 2.00 p.m.

COLLEGE REUNIONS

It has been the custom of certain of the technical schools to hold reunions in New York on the last day of the Annual Meeting (which this year will be December 4), to welcome the large number of out-of-town members. Complete details will be given in the program distributed at the Annual Meeting. The following reunions have been planned for that evening:

BROWN UNIVERSITY

The Engineering Alumni will hold a reunion dinner at the Brown Club, West 44th Street, at 6.30 o'clock. It is expected that Professor Wm. H. Kenerson will be toastmaster. Those desiring to attend are requested to communicate with Alfred F. Masury, Chairman, care of International Motor Company, 64th Street and West End Avenue, New York.

CORNELL UNIVERSITY

The Alumni of Cornell University are planning a reunion at the Cornell Club in which Cornell members of the Society and their guests are invited to participate. Further information may be obtained from H. O. Pond, care of Westinghouse, Church, Kerr & Co., 37 Wall Street, New York.

KENTUCKY STATE UNIVERSITY

The Kentucky State University Club of New York will hold a meeting on Friday evening, and invite all members of the Alumni to plan to be present as an enjoyable evening is anticipated. Information may be obtained from C. E. Daniel, 101 Park Avenue, New York.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

An informal dinner and "smoker" will be held at the Technology Club, 17 Gramercy Park, New York. All members of the Alumni Association of Massachusetts Institute of Technology are earnestly invited to be present. Full information can be secured by addressing G. F. Shaffer, Technology Club, New York City.

POLYTECHNIC INSTITUTE OF BROOKLYN

The Mechanical Engineering Alumni of the Polytechnic Institute of Brooklyn will hold a reunion in the rooms of the Society at 8.15 o'clock.

Edwin B. Katte, Vice-President of The American Society of Mechanical Engineers, will present an illustrated lecture on Electrification of the Grand Central Terminal. An invitation to attend is extended to all members of the Society as well as the Alumni of Polytechnic Institute.

PURDUE UNIVERSITY

The Purdue Club of New York City will hold its annual election of officers on the evening of December 4, 1914, and extend a cordial invitation to the Alumni of Purdue University to be present. This event always brings out a large attendance and affords an excellent opportunity for a reunion. E. W. Davis, Room 2101, 165 Broadway, New York, will furnish further details.

STEVENS INSTITUTE OF TECHNOLOGY

All members of The American Society of Mechanical Engineers and their guests are cordially invited to join with the Alumni of Stevens Institute of Technology in their annual theatre party on Friday evening, December 4, 1914, at the Knickerbocker Theater. After the show, there will be a supper and dance at the Hotel Astor. Tickets may be obtained from the Tyson Company, Hotel Astor. B. Franklin Hart, Jr., 50 Church Street, New York, is Chairman of the Committee in charge of the details.

WORCESTER POLYTECHNIC INSTITUTE

The Alumni of Worcester Polytechnic Institute will hold a banquet at the Machinery Club, 50 Church Street, New York, at 6.30 p.m. President Ira N. Hollis has promised to be present and Professor Harold B. Smith will make an address on Rambles in the Orient. Special arrangements are being made for a large reunion of all Worcester Polytechnic Alumni. F. O. Price, Pratt Institute, Brooklyn, has charge of the arrangements.

YALE UNIVERSITY

Tentative plans have been made for a reunion dinner to be held at the Yale Club. All graduates are invited to attend and participate in the formation of a Yale Engineering Society, which will take place on that evening. E. G. Williams, care of J. G. White Engrg. Corp., 43 Exchange Place, New York, will give desired information.

TRANSACTIONS AND THE JOURNAL

In accordance with the vote of the Council the annual volume of Transactions in the 6 by 9 size with the usual library binding will be issued to the entire membership during the coming year. This volume will cover the activities of the Society during the year ending with the present Annual Meeting.

In the January number of The Journal an Index for the twelve preceding numbers will be published, together with complete directions for binding.

COUNCIL NOTES

At a meeting of the Council on November 13, 1914, the reports of the Standing Committees were presented. These appear in this issue of The Journal.

The rules governing the award of the Henry Hess Prizes for Juniors and Student Members were approved as drafted by the Committee on Meetings and the chairman of the Committee on Student Branches.

It was voted to approve the formation of a student branch of the Society at Throop College of Technology, Pasadena, Cal.

The Committee on Constitution and By-Laws was requested to prepare amendments to the Constitution changing the present method of nominating officers.

The following Committee on Meetings in Milwaukee was approved: L. E. Strothman, Chairman; F. H. Dorner, Secretary; M. A. Beck, Henry Weickel, R. H. Robinson, W. C. Lindemann, Arthur Simons.

The Boiler Code again came up for discussion, and it was voted that the Code be reprinted after the insertion of certain corrections and that it be presented as a progress report at the Annual Meeting.

Calvin W. Rice, *Secretary*.

HENRY HESS PRIZES FOR TECHNICAL PAPERS

In the March issue of The Journal was announced the generous gift of Mr. Henry Hess of $2000, the income to be used for the awarding of prizes for technical papers from Junior and Student Members. Such an award offers a valuable aid to the young engineer to undertake original work and is in line with the practice of many foreign societies.

Rules have been drawn up and approved by the Council with reference to the distribution of these prizes, those governing the Junior papers having been formulated by the Committee on Meetings and those for the Student papers by the Committee on Student Branches. It is the hope of the Council that there will be a large number of papers submitted for the decision of the Committee on Prizes.

The conditions governing the award are as follows:

COMMITTEE ON PRIZES FOR JUNIORS

(1) The Council shall appoint annually, not later than its regular meeting in January of each year, three members of the Society, not members of the Council, who shall form a Committee to recommend the award of prizes for Juniors during the year. This Committee shall include one member of the Meetings Committee of the Society.

(2) The papers considered shall include all papers presented to the Society by Juniors during the year ending with the month of August.

(3) The Committee on Prizes shall report its recommendation to the Council on or before October—the findings of the Committee shall be final. Prizes shall be awarded by the Council. The awards shall be announced at the Annual Meeting and shall also be published in The Journal.

(4) The Secretary of the Society shall act as Secretary to the Committee on Prizes, but shall not be a member of the Committee.

RULES OF AWARD

(1) The competition for the prize shall be restricted to the Juniors of the Society.

(2) The prize shall consist of fifty dollars in cash and an engraved certificate, signed by the President and Secretary of the Society.

(3) The prize shall be awarded for the best paper of the year, provided such paper shall be adjudged of sufficient merit as a contribution to the literature of the profession of Mechanical Engineering, but not otherwise.

(4) Papers to be eligible for competition must be the bona fide production of those contributing them and must not have been previously made public nor contributed to any other society in whole or in part.

(5) If in any one year, no award be made, it shall be in the power of the Committee to award in the following year or years the accumulated prizes to the authors of the different papers deemed of sufficient merit.

(6) These rules may be modified by the Council.

COMMITTEE ON PRIZES FOR MEMBERS OF STUDENT BRANCHES

(1) The Council shall appoint annually, not later than its regular meeting in January of each year, three members of the Society not members of the Council, who shall form the Committee of Award to recommend the award of prizes from the Henry Hess Fund for Members of Student Branches of the Society during the year. This Committee shall include the Chairman of the Standing Committee on Student Branches.

(2) The Honorary Presidents of the Student Branches submitting papers in competition shall be asked to sit as Advisory Members to the Committee on Award.

(3) The papers considered shall include papers submitted by Members of Student Branches in competition during the year ending on August 31.

(4) The Committee on Award shall report its recommendations to the Council on or before October 1. The findings of the Committee shall be final. Prizes shall be awarded by the Council. The awards shall be announced at the Annual Meeting and shall also be published in The Journal.

(5) The Secretary of the Society shall act as Secretary to the Committee on Prizes, but shall not be a member of the Committee.

RULES OF AWARD

(1) The competition for the prizes shall be restricted to enrolled members of the Student Branches of the Society in good standing.

(2) The two prizes shall consist of twenty-five dollars each in cash, with an engraved certificate signed by the President and Secretary of the Society.

(3) The prizes shall be awarded for the best two papers presented during the year from October 1 to September 30 following, provided such paper shall be adjudged of sufficient merit to be a contribution to the literature of the profession of mechanical engineering, but not otherwise.

(4) Papers to be eligible to consideration in the competition must be the bona fide production of those contributing them; and must not have been made public nor contributed in whole or in part to any other body than the Student Branch in which they have originated.

(5) If no award of a prize is made in any year, it shall be within the power of the Committee on Award hereafter provided, to award in the following year or years the accumulated prizes to more than the two authors above specified, provided the papers in competition be deemed of sufficient merit.

(6) These rules may be modified by the Council, to take effect on the first of October next ensuing.

APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i.e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by ad-

vising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before January 10, 1915.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Allen, Harvey, Development Engr., Pressed Steel Car Co., and Western Steel Car & Fdy. Co., Pittsburgh, Pa.

Barba, William P., Genl. Mgr., Midvale Steel Co., Philadelphia, Pa.

Brenzinger, Julius, Vice-Pres. and Genl. Supt., Max Ams Mch. Co., Mt. Vernon, N. Y.

Foersterling, Hans, Second Vice-Pres., The Roessler & Hasslacher Chemical Co., Perth Amboy, N. J.

Foord, James L., Ch. Inspector, Hartford Steam Boiler Inspc. & Ins. Co., Chicago, Ill.

Goldsborough, Winder E., Cons. Engr., 30 Church St., New York.

Harley, Leon J., Jr., Pres., Harley Co., Sringfield, Mass.

Kelley, Wm. D., Genl. Supt., Meters, Consolidated Gas Co. of N. Y., New York.

Knowlton, Edward K., Supt. of Pwr., Standard Oil Co., Bayonne, N. J.

Lucey, Edmund A., with H. L. Gantt, Cons. Engr., New York.

Luckett, Gustavus T., Commercial Engr., The M. W. Kellogg Co., New York.

Macbeth, George T., Engr., Gas Dept., Westchester Ltg. Co., Mt. Vernon, N. Y.

MacIntosh, Walter L., Ch. Draftsman, Consolidated Gas Co. of N. Y., New York.

Mayland, G. Alfred, Engr. & Ch. Draftsman, Los Angeles Gas & Elec. Corp., Los Angeles, Cal.

Milliken, Albert D., Agent, Hamilton Mfg. Co., Lowell, Mass.

Mills, Anson C., Supt., Jackson Fence Co., Jackson, Mich.

Morhous, Oakley A., Chemist in Charge, Consolidated Laboratory, Consolidated Gas Co. of N. Y., New York.

Muschenheim, Frederick A., Vice-Pres., Hotel Astor, New York.

Neeland, Marvin A., Asst. to Vice-Pres., United States Steel Corp., New York.

Nelson, Charles, Ch. Engr. and Supt., Boiler & Fly Wheel Dept., Royal Indemnity Co., New York.

Oakley, Clifford H., Principal Owner, Pres. & Factory Mgr., Essex Rubber Co., Inc., Trenton, N. J.

Pressinger, Harry E., Deputy, Charge of Boiler Inspection, Industrial Commission of Wis., Milwaukee, Wis.

Radcliffe, Robert L., Mgr., St. Louis Office, Henry R. Worthington, St. Louis, Mo.

Schaeffer, Charles F., Prop. & Mgr., Schaeffer Mch. Wks., Philadelphia, Pa.

Scofield, Edward H., Engr. of Pwr., Twin City Rapid Transit Co., Minneapolis, Minn.

Spear, Maynard H., Secy. & Genl. Mgr., New York & Queens Gas Co., Flushing, N. Y.

Stevens, Everett M., Asst. Mgr. of Sales, Nashua Mch. Co., Boston, Mass.

Tappan, Charles O., Cons. and Constr. Engr., 2 Rector St., New York.

Thomas, Albert C., Resident Ch. Engr., Alpha Portland Cement Co., Easton, Pa.

Underhill, Henry L., Asst. Engr. of Manufacture, Consolidated Gas Co. of N. Y., Astoria, L. I., N. Y.

Woods, George E., Asst. Ch. Engr., Consolidated Gas Co. of N. Y., New York.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Fry, Henry S., Div. Supt., H. C. Fry Co., Rochester, Pa.

Jablow, Charles, Associate Prof. of Mech. Engrg., Oklahoma Agri. & Mech. College, Stillwater, Okla.

Leslie, Bernard S., Asst. to Supt. of Factory, United Shoe Mchy. Co., Beverly, Mass.

MacNaughton, Edgar, Instr. in Mech. Engrg., Tufts College, Tufts College, Mass.

FOR CONSIDERATION AS JUNIOR

Conner, B. Franklin, Jr., Engr., Alberger Pump & Condenser Co., Newburgh, N. Y.

Dalrymple, Philip W., Ch. Engr., Factory No. 10, The Singer Mfg. Co., Bridgeport, Conn.

Herr, George D., Mech. Engr., Sayles Bleacheries, Saylesville, R. I.

McKendrick, Leslie, Engrg. Rep., Wheeler Condenser & Engrg. Co., New York.

Malone, John A., Asst., Standard Oil Co. of N. Y., Bombay, India.

Penney, Charles F., Sales Engr., Combusto Devices Corp., care R. Lendermann, New Haven, Conn.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE

Graves, James M., Supt., Pwr. Sta., Duquesne Light Co., Pittsburgh, Pa.

PROMOTION FROM JUNIOR

Greger, Henrik, Asst. Ch. Engr., Epping-Carpenter Pump Co., Pittsburgh, Pa.

Murray, Arthur F., Rep., International Steam Pump Co., St. Paul, Minn.

Seaton, Roy A., Prof., Kansas State Agricultural College, Manhattan, Kansas.

Tracy, Lyndon S., Mgr., Soda Ash Dept., The Solvay Process Co., Syracuse, N. Y.

SUMMARY

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REPORTS OF STANDING COMMITTEES

Presented at the Council Meeting, November 13, 1914

COMMITTEE ON CONSTITUTION AND BY LAWS

The President appointed as members of the Committee on Constitution and By-Laws, Jesse M. Smith, Chairman, F. R. Hutton, Alfred Noble.

The Committee has recommended and the Council approved the amendments to By-Laws 2 and 3, whereby By-Law 3 is renumbered By-Law 2 as a more logical arrangement; former By-Law 2 is renumbered By-Law 3 and reworded, and permits the use of non members as references for a candidate who is so situated as not to know or come in contact with members of the Society, yet in every other way is eligible to membership.

B 3 Applications for membership from candidates who may be so situated as not to be personally known to the necessary number of members of the Society may be recommended by the Membership Committee for ballot, after sufficient evidence has been secured to show that in its opinion the applicant is worthy of admission to membership. Such applicant for membership may refer to officers or voting members of other engineering societies of like standing.

The Amendments to the Constitution as announced by ballot at the Spring Meeting in St. Paul-Minneapolis are now in effect, and are as follows:

C 9 A Member shall be an Engineer or Teacher of Applied Science of thirty-two years of age, or over, and shall have been in the active practice of his profession for at least ten years and in responsible charge of important work for five years, and shall be qualified to design as well as to direct engineering work. Fulfilling the duties of a Professor of Engineering who is in charge of a department in a college or school of accepted standing shall be taken as an equivalent to an equal number of years of active practice. Graduation from a school of engineering of recognized standing shall be considered as equivalent to two years of active practice.

C 11 An Associate-Member shall be a professional engineer not less than twenty-seven years of age, who shall have been in the actual practice of his profession for at least six years, and who shall have had responsible charge of work as principal or assistant for at least one year. Graduation from a school of engineering of recognized reputation shall be considered as equivalent to two years' active practice.

Respectfully submitted.

JESSE M. SMITH, *Chmn.* }
FREDERICK R. HUTTON } *Committee on Constitution and By-Laws*

REPORT OF FINANCE COMMITTEE

Your Finance Committee reports that the income of the Society for the year ending September 30, 1914, was $125,454.11; the total expenditures chargeable to income, $116,001.67, leaving an excess over income of $9,152.44. Of this amount, it is recommended that $1000 be reserved for distributing Vol. 35 of the Transactions and $3500 for completing the September 1914, issue of Condensed Catalogues, leaving $4,952.44, which it is recommended be turned into reserve fund. It is further recommended that all appropriations in excess of actual expenditures be cancelled.

Your Finance Committee recommends for the budget for the year to end September 30, 1915, as follows:

Finance Committee	$26,960
Membership Committee	2,000
Increase of Membership Committee	5,000
Council	7,500
House Committee	1,750
Meetings Committee	7,200
Publication Committee	55,500
Research Committee	100
Public Relation Committee	500
John Fritz Medal	150
Engineering Congress	2,000
Sales	8,000
Total	$116,660

It is estimated that the income will be $130,500.

It has been the policy of the Finance Committee to regulate the disbursements of the Society each year so that they will be but 90 per cent of the income. During the year just closed, these expenses amounted to approximately 95 per cent of the income.

On an expected income for the current fiscal year of $130,500, the aggregate of appropriations is $116,660, or approximately 90 per cent. It should be understood that as the year progresses, if the income of the Society shall give evidence of exceeding the above estimate, then, in case of necessity, appropriations may be increased; but if, on the other hand, there will be evidence of a falling off in the estimated income, the activities of the Society should be regulated so that the expenses will, as far as possible, be proportionately decreased.

Appended will be found a report of the accounts of the Society as shown in the books for the fiscal year ending September 30, 1914.

Respectfully submitted.

R. M. DIXON, *Chmn.*
W. H. MARSHALL
H. L. DOHERTY
W. L. SAUNDERS
W. D. SARGENT
Finance Committee

APPENDIX TO REPORT

October 14, 1914

MR. R. M. DIXON,
CHAIRMAN, FINANCE COMMITTEE

Dear Sir:—

In accordance with your instructions, we have examined the books and accounts of The American Society of Mechanical Engineers, for the twelve months ended September 30, 1914.

The results of this examination are set forth in the three exhibits, attached hereto, as follows:

Exhibit A Balance Sheet, September 30, 1914.
Exhibit B Income and Expenses for the twelve months ended September 30, 1914.
Exhibit C Receipts and Disbursements for the twelve months ended September 30, 1914

We hereby certify that the accompanying Balance Sheet is a true exhibit of its financial conditions as of September 30, 1914, and that the attached statements of Income and Expenses, and Receipts and Disbursements are correct.

Respectfully submitted,

WM. J. STRUSS & CO.
Certified Public Accountants

EXHIBIT A

BALANCE SHEET, SEPTEMBER 30, 1914

ASSETS

Equity in Society's Building (No. 25 to 33 W. 39th St.)	$353,346.62	
Equity one-third of Cost of Land (No. 25 33 W. 39th St.)	180,000.00	
		$533,346.62
Library Books	13,000.00	
Furniture and Fixtures	5,000.00	
		18,000.00
Stores, including Plates and Finished Publications		16,581.61
Trust Fund Investment		
New York City $3\frac{1}{2}$% Bonds 1954 (Par $45,000)	$39,696.81	
St. Louis, Peoria & N. W. 1st 5's 1948 (Par $10,000)	10,613.89	
Cash in Banks representing Trust Funds	31,977.41	
		$82,288.11
Cash in Banks for General Purposes	$7,374.92	
Petty Cash on hand	500.00	
		7,874.92
Accounts Receivable		
Membership Dues	$10,079.79	
Initiation Fees	4,080.00	
Sales of Publications, Advertising, etc.	21,960.46	
Total		36,120.25
Advance Payments		1,569.52
		$695,781.03

LIABILITIES

Certificates of Indebtedness		$60,300.00
Trust Funds		
Life Membership Fund	$43,500.00	
Library Development Fund	4,902.71	
Weeks Legacy Fund	1,957.00	
Initiation Fee Fund	29,928.10	
Henry Hess Prize for Juniors	1,000.00	
Henry Hess Prize for Students	1,000.00	
		$82,288.11
Dues Paid in Advance		1,951.75
Initiation Fees Uncollected		4,080.00
Initiation Fees paid before due		25.00
Unexpended Appropriation 1913–14		4,704.39
Unappropriated Revenue 1913–14		4,748.05
U. S. Internal Revenue Account		10.64
Accounts Payable		3,905.28
		$162,013.22
Capital Investment	$491,046.62	
Surplus and Reserves	42,721.19	
		533,767.81
		$695,781.03

EXHIBIT B

INCOME AND EXPENSES, FOR THE 12 MONTHS ENDED SEPTEMBER 30, 1914

INCOME

Membership Dues	$73,541.35	
Sales, Gross Receipts	10,055.42	
Advertising	39,578.99	
Interest and Discount	2,278.35	
Total		$125,454.11

EXPENSES

Finance Committee	$23,003.91	
Membership Committee	2,138.47	
Council	7,169.31	
Increase of Membership Committee	6,182.93	
House Committee	2,270.49	
Library Committee	4,127.50	
Meetings Committee	7,379.51	
Publication Committee	56,205.24	
Advertising	22,343.76	
Journal Text	21,084.15	
Revises	181.57	
Transactions	8,694.64	
Year Book	3,901.12	
Research Committee	18.11	
Boiler Specifications Committee	1,227.35	
Power Test Committee	895.61	
German Resolution Fund and Dinner	281.18	
Annual Meeting Social	182.74	
Sales Expenditures	6,419.02	
Engineering Congress	1,250.00	
Total	$118,751.67	
Expenses Chargeable to Reserve	2,750.00	
		116,001.67
Excess of Income over Expenses		$9,452.44

$1000.00 to be reserved for distributing Vol. 35 Transactions.
$3500.00 to be reserved for completing Sept. 1914, Condensed Catalogues.

EXHIBIT C

RECEIPTS AND DISBURSEMENTS FOR THE 12 MONTHS ENDED SEPTEMBER 30, 1914

RECEIPTS

Membership Dues	$69,516.27	
Initiation Fees	27,085.00	
Membership Dues, Initiation Fees paid in advance	2,546.93	
Sales of Publications, Badges, Advertising, etc.	41,667.19	
Interest	3,414.49	
U. S. Internal Revenue	10.76	
	$144,240.64	
Cash in Banks and on hand General and Trust Funds, September 30, 1913	39,905.52	
		$184,146.16

DISBURSEMENTS

Disbursements for general purposes	$117,108.13	
Bonds Purchased	19,385.70	
Certificates of Indebtedness Redeemed	7,800.00	
	$144,293.83	
Cash in Banks and on hand General and Trust Funds, September 30, 1914	39,852.33	
		$184,146.16

REPORT OF THE HOUSE COMMITTEE

Again as in recent years, the House Committee, in addition to its routine duties, was responsible for the manage-

ment and conduct of the President's reception on the occasion of the Annual Meeting of 1913.

Several new portraits of honorary members have been hung in the Secretary's office and the collection is now practically complete.

The office equipment has been augmented by the addition of several desks, filing cabinets and the replacing of worn typewriters, etc.

The inventory of the pictures, equipment, books, stores and publications belonging to the Society, begun in February 1913, has been maintained and brought up to date.

Plans have been formulated for certain alterations in the Society's rooms whereby three rooms will be thrown into one large room for use as a business office by the Society, but the work has been deferred until more favorable times.

Respectfully submitted,

H. R. Cobleigh, *Chmn.*
S. D. Collett
W. N. Dickinson
F. A. Scheffler
J. W. Nelson

House Committee

REPORT OF THE LIBRARY COMMITTEE

It is with deep regret that the Library Committee is obliged to report the death of one of its most valued members, Mr. Alfred Noble, on April 19, 1914. From the organization of the Library Board of the United Engineering Society he took the liveliest interest in the library, devoting much time and thought to its activities. The Board has adopted appropriate resolutions, an engrossed copy of which has been presented to Mr. Noble's family.

During the year ended September 30, 1914, there has been added to the library of the Society, 1039 volumes and 185 pamphlets. Of the bound volumes, 303 were purchased, 302 were received in exchange for The Journal and Transactions, and 327 were presented. The pamphlets were largely received in exchange.

The attendance during the year has substantially increased; 13,485 persons used the library during the year, as compared with 10,357 last year, a gain of about 30 per cent. The library hours have been extended until 10 p.m., instead of 9 p.m., and the evening attendance has proportionately increased.

A catalogue of the sets of technical periodicals in the libraries of New York and vicinity is nearing completion. It will be ready for the printer about January 1, 1915.

A large amount of research work has been carried on, in the preparation of reference lists for members and others.

Respectfully submitted,

Leonard Waldo, *Chmn.*
Jesse M. Smith
W. M. McFarland
J. W. Lieb, Jr.
The Secretary

Library Committee

REPORT OF THE COMMITTEE ON MEETINGS

During the year 1913-1914 the Committee on Meetings has met six times and purposes to hold several more committee meetings before the Annual Meeting of the Society in December. One of the important features of this year's work has been the unusually early preparation of the programs of the Spring and Annual Meetings of this year and the Spring Meeting of 1915. This action has been taken with the belief that through it a better average quality of papers and more comprehensive treatment of subjects can be obtained. This has involved somewhat more work during this year than usual, but this will clear the ground for a continuation of the policy in the future, without unusual effort. This policy follows the admirable example set by some of the great British societies.

Three professional sessions were arranged for at the Spring Meeting in St. Paul and Minneapolis: one was a symposium dealing with the use of powdered coal fuel; another was devoted to miscellaneous papers; the third related to engineering work in the vicinity of the Twin Cities. The papers for this last session were solicited by the Local Committee, and it is a pleasant duty to acknowledge the hearty coöperation of its members.

The plans for the Annual Meeting were worked out as early as January 2, 1914, and a tentative program published in the February issue of The Journal. A request was made to have as many of the papers as possible in the hands of the Committee by September 1, or immediately thereafter. At the date of writing this report (October 1), the greater part of the papers for the Annual Meeting have been received, and many of these have already received final action.

Committee meetings between this date and the Annual Meeting will be devoted largely to the program for the Spring Meeting of 1915.

The importance and value of the work of the sub-committees is becoming more and more evident. In working out the program for the Annual Meeting, the coöperation of four sub-committees deserves especial mention and a large measure of appreciation, namely, that of the Machine Shop Practice, Railroads, Hoisting and Conveying, and Iron and Steel Committees.

In addition, the standing Committee on Public Relations has carried forward the preparations for one session to be devoted to the subject of the Engineering in Connection with the Administration of Cities.

The results of the past year, combined with former accumulated experience in the work of sub-committees and their relations to the Committee on Meetings, show the need of a more clearly defined policy to bring about uniformity of action and the largest measure of effectiveness in those relations. To point out a single feature, there should be a uniform time and method for reconstituting the membership of the sub-committees. This will bring more of our members into active Society work and should tend to enrich and increase the technical value of the papers and reports brought forth.

The committee feels compelled to point out that the rapidly growing membership of the Society requires a more and more diversified engineering program for the meetings, and this in turn requires increasing appropriations to carry on the work.

Respectfully submitted,

L. P. Alford, *Chmn.*
H. E. Longwell
H. L. Gantt
R. H. Fernald
J. H. Barr

Committee on Meetings

REPORT OF COMMITTEE ON MEMBERSHIP

During the past year the Committee on Membership has held 12 meetings for the transaction of its work.

The number of applications acted upon during the fiscal year 1913-14 are as follows:

Applications pending October 1, 1913	329
Applications received during fiscal year	1192
Total	1521

Of these applications the following action was taken:

Recommended for membership	1318
Withdrawn for various reasons	1
Deferred indefinitely	9
Denied promotion	2
Deferred for special investigations	48
Irregular course of procedure	143
Total	1521

This total was divided into the following gradings:

Members	588
Promotions to Member	81
Associates	59
Associate-Members	245
Promotion to Associate-Members	57
Juniors	288
Total	1318

It was also voted to recommend to the Council the reinstatement of 15 members.

The Committee maintained and continued the careful scrutiny of the past in the admission of members and yet has simplified and standardized the procedure so that the cost has been reduced. The success may be measured by the following figures:

Year	Cost	No. Applications	Cost, each	Reduction, Per Cent
1911–1912	$3567	694	$5.14	..
1912–1913	3281	868	3.78	26
1913–1914	2171	1330	1.63	68

During the year the Committee voted against granting the Junior grade to any applicant thirty years of age or over on the ground that a candidate who at thirty years of age does not possess qualifications for a grade higher than Junior will not be a credit to the Society or help to keep up the present high standard of membership.

During the year a woman was admitted to membership for the first time in the history of the Society.

It will be observed that the number of applications greatly exceeds the numbers of previous years, and that the applicants include many prominent engineers. The Society is being strengthened thereby and aided towards a much needed occupation of the wider fields of activity appropriate to the profession. For this growth of numbers we are all largely indebted to the fruitful activities of the Committee on Increase of Membership and its Chairman.

Respectfully submitted,

THEO. STEBBINS, *Chmn.*
W. H. BOEHM
H. C. MEYER, JR.
L. R. POMEROY
HOSEA WEBSTER

Membership Committee

REPORT OF THE PUBLICATION COMMITTEE

In accordance with the recommendations of the Committee in its last annual report, several important changes in the publications of the Society were effected in January 1914. For several years the Publication Committee has sought to devise a plan which would eliminate the duplicate publication of papers in the Transactions and in The Journal. In October 1913 the Committee presented a plan to the Council providing for the increase in size of The Journal and the abolishment of the Transactions, with the recommendation that the question of abolishing the Transactions be referred to the members. The Council approved the entire recommendations except the referendum to the members.[1]

The result has been the issuing of The Journal in its new form in the 9 in. by 12 in. size, which is gradually becoming the standard for technical periodicals. The matter in The Journal is so arranged that the papers and discussions are brought together in the same issue after a meeting instead of being separated in different issues as heretofore. When published in this manner The Journal becomes the Transactions of the Society and has the advantage of bringing the reports of meetings to the attention of the membership when the matter is new, instead of a year after presentation.

In its mechanical make-up, The Journal is produced in sections to facilitate binding. The first part contains information upon Society affairs and announcements of meetings. Previous to the Annual and Spring meetings abstracts are published of the papers to be presented so that members may be informed and may send for such pamphlet copies of the papers as they may desire. The second section contains the papers and discussion given at meetings, after which is the Foreign Review Section.

A gratifying commentary on the foregoing plan has been the recent adoption by the British Institution of Mechanical Engineers of the same plan, except that the small size of page has been maintained for their Journal.

An alternative plan preferred by Mr. Low of the Committee, outlined in The Journal for April 1914, has been carefully considered. This involves:

a Printing the papers separately, as usual, for distribution before the meeting

b Making The Journal's treatment of the papers and the meetings a readable account of what they contain and accomplish

c Binding the papers separately in paper covers, each with its discussions, rather than binding them all together in the Transactions

Members will be advised in The Journal of the papers which are to be presented at a coming meeting and can obtain gratis copies of any or all of them by addressing the Secretary. They will thus have in The Journal (*a*) a copy of each paper in full or in abstract; (*b*) an account of its presentation at the meeting and of the discussion which it brought forth; and in addition they can have upon request (*c*) complete finished copies of the papers neatly bound with their discussions.

A member who wants to keep the Transactions as he has been doing can simply request a copy of each paper presented during the year with its discussions, and get them bound in the style of former years. Those who want to specialize more can order the papers in which they are specially interested, and bind or file them as they see fit. Papers upon the same or similar subjects can be bound together into monographs or symposiums, and in addition the members can bind their Journals if they wish, either in whole or in part, provision having been made in the paging for eliminating conveniently the several departments and the matter of merely present or passing interest.

[1] The Council at its October meeting voted to issue Transactions in the usual form in 1915.

During the year approximately 75 letters of criticism have been received from the membership of 5500 and in three cases from groups of members, in which the chief objections have been the abolishment of the bound volumes of Transactions and the fact that if bound copies of The Journal were to constitute the Transactions, they would be an inconvenient size for book shelves. Although the number of objections is small in proportion to the membership, the earnestness of the communications and the preference expressed in them for the established custom of issuing Transactions in an annual volume convinces the Committee that the decision to retain or discontinue the annual volume should be made by the membership at large.

The Committee has made such provision that the continuance of Transactions in its old form shall be possible. The volume has recently been issued for 1913-1914 and throughout the year the papers have been printed in pamphlet form in the small size and the type kept standing. These pamphlets are available for a 1914-1915 volume of Transactions, should the Council or the membership so elect.

The Index for the first 35 volumes of Transactions, with the exception of Vols. 31, 32 and 33, which was prepared for the printer over a year ago, is still unpublished because of the lack of funds at the disposal of the Committee.

Respectfully submitted,

Chas. I. Earll, *Chmn.*
Geo. M. Basford
I. E. Moultrop
Fred. R. Low
Fred J. Miller

Publication Committee

REPORT OF THE RESEARCH COMMITTEE

During the year, the Committee has appointed, subject to the approval of the Council, a committee on research into the subject of Fuel Oils.

This committee has organized and begun work, but no results have been obtained which are sufficient to warrant a report. The committee is, however, active and enthusiastic, and it is expected that it will be able to show at the end of another year excellent results.

The Sub-Committee on Safety Valves, appointed by the Committee and sanctioned by the Council, organized with P. G. Darling as chairman. In response to a request for a report of the activities of the sub-committee, Mr. Darling writes that his location for the ensuing year will be so inaccessible that he will be unable to take part in the activities of the committee, and that Edward F. Miller has been appointed as chairman pro tem. Professor Miller reports that considerable work has been done and that a more complete report will be made later.

The Sub-Committee on Materials of Electrical Engineering, consisting of Ralph D. Mershon, reports that Professor Boyd of the Ohio State University has been doing, on the request of the committee, some experimental work on porcelain and other ceramic material in order to determine their mechanical characteristics.

The Sub-Committee on Steam has not been able to make any progress during the year on account of the absence of material.

So far as the activities of the Research Committee itself are concerned, a communication was recently received from an engineer of the highest standing, who desires to make research on the properties of worm gearing. Correspondence on this subject has been taken up with a prominent manufacturer, and, under certain conditions, the assent of this company has been secured to a monetary contribution. The matter is being actively prosecuted and it is believed that funds can be secured for this investigation.

The membership of the Society does not seem to appreciate the existence of the Research Committee or avail itself of the facilities which the Committee offers. Great activity has been shown by various members of the Committee and its sub-committees in the suggestion of directions in which the work of the Committee could be carried on, but these suggestions on the whole have not borne definite fruit. The Research Committee feels that if it is to be of real use to the Society the stimulus to such use must come from the members themselves in bringing before the Committee problems which need solution, and in notifying the Committee of desire to make investigations, and taking advantage of the Committee's facilities for enlisting the coöperation, both financial and otherwise, of manufacturers and others interested in the subjects under investigation.

Respectfully submitted,

Richard H. Rice, *Chmn.*
A. L. De Leeuw
Rolla C. Carpenter
Ralph D. Mershon

Research Committee

REPORT OF PUBLIC RELATIONS COMMITTEE

Arrangements are being made for conducting, under the guidance of the Committee, a session of the Society to be held at the coming Annual Meeting, at which session subjects dealing with the relation of the engineer to public work, and especially to such engineering work as is done by municipalities, will be presented and discussed, not from the political point of view, but from the engineer's side.

This action has been taken by the Committee in the belief that the Society should take note of the fact that the engineer is being more and more recognized as a very important factor in conducting such work as is done by municipalities in the interest of the public; that the day has gone by when his only function will be employment as a consultant or expert; and that he will be increasingly called upon to serve in positions of general executive character where his training and special knowledge will be available and can be applied in direct service to the public.

The Committee believes that it will be wise for the Society, while avoiding the discussion of the political side of this matter, to recognize the facts of the situation and to advance, so far as may be possible, this general movement toward a greater recognition of the valuable services that can be rendered by engineers in executive positions.

Respectfully submitted,

Fred J. Miller, *Chmn.*
Jas. M. Dodge
Worcester R. Warner
Geo. M. Brill
Morris L. Cooke

Public Relations Committee

PANIC ECONOMIES AND EMERGENCY PROBLEMS WITH ESPECIAL REFERENCE TO THE PRESENT INDUSTRIAL SITUATION

BY F. A. WALDRON, NEW YORK

Member of the Society

PANICS, business depressions or financial stringencies are primarily due to the suspension of credits in one form or other. From eighty to ninety per cent of the business in this country is done upon a thirty to ninety days' credit, and where a condition arises which causes a disturbance of these credits, naturally there is a rush to conserve, or hold cash, and be prepared for any unusual demand that may be made for coin of the realm.

Many theories have been advanced as to the repetition and psychology of these depressions, all of which have been more or less exploded in the last ten years.

Securities, or collateral, in themselves are credits of indefinite amounts on which the borrower agrees to pay a certain interest. These are termed investments in which the accumulated cash or credit of the individual are transferred from financial institutions to the purchase of such securities. These again appear as credits when banks loan on them a per cent of their value.

Securities, like any other commodity, have a fluctuating price aside from their interest-bearing value largely dependent on the supply and demand. On gilt edge securities in prosperous times, financial institutions will loan from seventy to eighty per cent of the market value. When an emergency arises demanding the coin of the realm or gold payments on all business transactions, there is a rush on the part of those holding securities to turn them into cash. This rush naturally floods the market and causes a serious drop in prices which in turn require the banks to demand payments to protect resources and cash loans on such securities. This is termed " the calling of loans," in which the one borrowing is obliged to pay the borrowed money in cash and receives in return his securities. If this payment cannot be met, the securities are immediately sold, which increases the supply and helps the downward trend.

The above is what might be termed the initial suspension of credits in which long term credits are suspended at their source and its effect on the entire industrial situation is generally widespread and harmful, as it affects commercial paper issued by industrials in obtaining ready cash for payrolls and materials.

This results in curtailing expenses by purchasing materials in smaller quantities and reducing payrolls, which in turn produces another reactive and accumulative feature, as each person thrown out of employment reduces the purchasing power of a community, curtails the amount of money in circulation and affects directly the volume of business done. Therefore, when these persons are unemployed, they are dependent on odd jobs at reduced rates, savings banks deposits or other small investments, the kindness of friends and relatives, and, in many cases, all club together and reduce living expenses to a minimum.

To meet the demands of depositors in savings and other banks or holders of securities in small amounts, it is necessary that financial institutions conserve cash to meet demands and hold heavy cash reserves. Therefore, when a depression or panic starts, it is like a cyclone, as there is added to the pressure or velocity of the wind, the falling weight of houses or trees upon those that are standing in its path, and only the strongest are able to resist. Channels of circulation are then narrowed down, credits withdrawn and the efforts of financial institutions are concentrated and localized in order to meet demands upon cash reserves demanded by depositors.

Realizing that the savings banks deposits of this country are about \$1,500,000,000, in amounts of one dollar to \$3,000, the result of 2,000,000 men drawing from these institutions at the rate of \$10 per week each, will give some idea of the amount needed. Most of the money thus withdrawn finds its way back to usual channels of circulation, but the " volume and rate of flow " is greatly reduced, resulting in tight money and slow collections.

In considering scientific adjustment of industrial finances during times of depression, there are a few elementary facts that control, all of which can be enlarged upon, almost to infinity. It is the purpose of this paper to place before you a few principles, leaving personality secondary; and if correct assumptions are made, the personal equation can be adjusted closely and satisfactorily with practical and reasonable accuracy.

The present situation has been suddenly and without warning forced upon us and we are at present facing a " condition and not a theory." That there is something wrong we all know, but what is it and how can it be remedied or made the least harmful, and what lesson can we learn? The question now is how to meet it and the problem is how can a recurrence be less harmful in the future.

Paper presented at the New York local meeting of The American Society of Mechanical Engineers on Oct. 21, 1914

To meet the question requires immediate and drastic action in most cases, but this action should be taken with due care and scientifically lest the pendulum swing too far. This is the industrial age in which products of the base metals are paramount and any permanent setback will be sufficient to stop the wheels of progress for some years to come. Therefore, it should be emphasized that whatever is done should be done scientifically with a broad spirit and a regard for the future.

There has been a decided tendency in the last few years for our industries to take too liberal view as to future possibilities, and instead of storing up in their organization kinetic energy by impartial and broad methods, stock dividends have been declared, and large and extravagant buildings have been erected without regard to the maximum possibilities obtainable by a broad and flexible common sense management and the natural healthy growth of the market conditions. In fact, some are or have been hypnotized by " systems " until it is hard for them to find out where they are at. Many believe that when a system is installed that is all; but a system, however good, is dangerous unless it has at its head a man with broad experience and hard business common sense. It is in just such emergencies as the present one that such a man is the most valuable and saves his salary many times over, and those who have not such are now feeling the greatest pressure.

In order that a preliminary survey may be made of the condition confronting an industry, the following facts should be determined as closely as possible:

1 Duration of period of depression and earning power;
2 Attitude of banks towards you and their condition;
3 Resources and liabilities;
4 Cash on hand and available;
5 Realization of cash from resources;
6 Attitude and condition of competitors;
7 Possibilities of market by reducing prices;
8 Flexibility of organization.

The extent of a *period of depression* is placed first as the net resources divided by this time regulate the daily or weekly expenditures.

The *attitude and condition of banks* directly affects resources, as excessive rates of interest, refusal to loan on commercial paper or collateral, in usual amounts, means a serious reduction in net resources, as it not only affects you direct, but also your debtors and creditors.

Resources and liabilities are then largely dependent on items 1 and 2 as to the amount and time.

As 90 per cent of the business in this country is done on credit and is effected by items 1, 2 and 3, the *cash on hand and available* becomes the next in importance and blessed be he who has enough " to keep the wolf from the door."

In business as well as private life, the cash in hand is small in proportion to the amounts required to conduct business or live. Therefore, the next step is *realizing* on commercial paper, collateral and other security.

Having determined how internal and outside influences will affect the financial question, it can generally be assumed that most *competitors* are in the same position, but not always. It is his preparedness to continue business that will influence the rate of operation and the reducing of salaries, wages, and material costs, as very few people care to lay off in the most depressing periods, men who are indispensable to their organization.

Some enterprising firms have gone out in times of depression, *reduced prices* and compelled purchase of their product. While this has kept the wheels turning, it has also stocked up the market and simply defers the recovery of normal prices.

In economizing in item No. 5, efficiency as a workman should be considered first and where efficiency is equal, married men should be given preference. Where records of performance are kept, this becomes an easy task and is less likely to be unfair than where personal influences of foremen or gang bosses are the criterion of retention of employees.

The reduction of salaries is a delicate question, as there is no measure of efficiency other than the general results; these results are oftentimes absolutely dependent on the judgment of the ability, knowledge and personality and capacity for growth and time of employment. It may also involve a question of contract or the demand by competitors for the services of the individual. This situation is generally handled with temporary reductions by mutual consent of both parties, such reduction to be restored when times will warrant.

Frequently an executive can make a good showing the first or second year, but he has sacrificed other things to do it and the ensuing years show a drop which is so well covered as to be hard to locate, and the process of applying the remedy is involved and difficult. Sometimes it is a gradual running down of quality resulting in heavy expense for travel and trouble of investigation. I know of one case where it took thousands of dollars and five years for a company to gain the prestige back that it lost in two years of so-called factory management, in which rates were indiscriminately cut and the quality of work thereby slighted.

Flexibility of organization is last but not least, on the list. With proper arrangement of duties and the training of chiefs of divisions, superintendents and workmen, the contracting of the working force be-

comes easy, not only from a financial standpoint, but an equitable one.

After the conditions of resources have been carefully reviewed and considered, the present rate of expenditures should be tabulated in detail and shown graphically, under the following headings:

A Executive—including salaries of all officers of the company; fixed corporate charges.

B Sales—including advertising, development work, managers, salesmen, traveling expenses, rents, etc.

C Manufacturing—including all fixed charges, such as rent, taxes, depreciation, etc.; all non-productive wages; all productive wages.

With resources determined and present rate of expenditure and the time which the depression is likely to last, a rate of reduction is determined which is to be applied to each of these three divisions, in proportion to the value of the services in each, eliminating all expense not absolutely required to conduct business through the depression. The best way to approach this is as follows:

a Eliminate all work which is not profitable, such as inventions, new product, new design, indiscreet advertising, traveling expenses;

b Cut down, if necessary, working hours, especially where it relates to reserve stock on hand, working on orders only;

c Study the possibility of combination and rearrangement of duties in executive, sales and manufacturing;

NOTE: *Flexibility of organization* is very helpful at this point.

d Temporary reduction of executive salaries;

e Temporary reduction of all salaried employees, receiving above a certain amount ($100 per month is the usual limit);

f Reduce the number of non-producers to a minimum;

g Reduce the number of producers;

h Reduce wages (to be avoided if possible).

Having reviewed the causes and effects, let us now analyze the best way of meeting the question of reducing number of employees, by a fair valuation of service and a consideration of the influences at work to retain or discharge an employee with the idea in view of obtaining the most efficient results and of being just.

Influences: Influences as to the retention of employees are often inductive and subtle when analyzed, much more so than most employers care to admit in public, and may be classified as follows: 1, Nepotism; 2, Sentiment; 3, Influence and friendship; 4, Politics; 5, Lack of inertia (laziness); 6, Misguided judgment; 7, Improper placing of individual; 8, Technicalities; 9, Disease and old age; and 10, Ability.

Ability is placed last, as the others are generally mentally formulated and cause a plus and minus sign to be affixed to it. If a man gets " in Dutch," it is easy to find some excuse to " fire " him.

Kinetic Energy of Production: In principle there is very little difference between the demands made on the manufacturer of a commodity and a public service corporation as each, in order to be successful, must be prepared to meet promptly and efficiently at reasonable profit the demands of the consumer. The manufacturer may well study the public service corporation and obtain many helpful points in keeping investment in plant down and yet be able to supply the peak load demand.

The old plan was to have large plants and investment with ample margin for peak loads, which resulted in heavy depreciation charges, increasing cost of power as the load factor was low. This is now changed. Turbines and generators are put in to stand an overload; boilers are placed with regard to economic fuel consumption for average load with organization and facilities for forcing boilers at time of peak load to twice their normal capacity or more, by auto stokers, forced draft and high grade coals. These elements of quick response to urgent demand might be termed the *Kinetic Energy of an Organization*, and applying the parallel to industries, we have roughly the following:

a Specific assignment of duties to men and machines;

b Currency of tools;

c Flexible methods of detail accounting tied in with manufacturing;

d Uniformity of machine tools, to receive jigs, cutters and fixtures;

e Preparation of methods for compensating labor;

f Maintaining buildings and equipment in first-class condition that have to do directly or indirectly with the turning out of product; and

g Accessible supply of raw materials.

Items *a* to *f*, inclusive, are within the control of the manufacturer. Item *g* should be looked at from a broader viewpoint. Manufacturing is a business on which a reasonable profit is expected and yet many firms make, while more loose, on speculative buying of pig iron, copper, tin, zinc and other raw materials.

a—Specific Assignment of Duties to Men and Machines: The duties of various executives of important and minor responsibilities should be studied carefully and arrangement made by which these duties can be analyzed. From this analysis the ones that are absolutely necessary should be kept in mind and the unimportant ones eliminated. From this, duties can be assigned and rearranged and the working force reduced, either by the laying off of those not required or temporarily reducing them to the ranks until such time as business may warrant reinstatement.

The capacity of machines should be carefully studied, together with the operations, and such operations assigned as will enable one man to run as many machines as he possibly can with a view of obtaining

the proper quality of work at a reduced rate and reduction in the number of the working force. This is a most important item and should be studied with the idea of making the changes in such a way that they will admit of prompt rearrangement and enlargement as business demands increase.

b—Carrying of Tools: One of the most defective points to-day in the development of the kinetic energy of an organization is the lack of supply, arrangement and assignment of tools, jigs and fixtures. Special effort should be made to study production and see that the standards, methods of making tools, stock carried, etc., should be such as to insure the continuous operation of the machines on which they are used.

c—Flexible Methods of Detail Accounting Tied in with Manufacturing Processes: A flexible method of detail accounting devoid of red tape and arranged so as to give the most efficient factory operation, is of paramount importance when a period of depression appears. If the method is flexible, it allows of prompt elimination of numerous clerks without interfering with the accuracy of the data which the proper shop accounting method gives. It also eliminates at all times unnecessary red tape and influences the manufacturer to study closely and scientifically the requirements of his factory by a simple review of manufacturing and stock records.

d—Uniformity of Machine Tools: This item is probably one of the most important, as it affects items *a*, *b* and *c*. By having uniform tapers, width of tee slots, speed and feed mechanisms, counter shafts, etc., alike, it enables the manufacturer to respond promptly to an increased demand and also to spread work over a large number of machines operated by one man in times of depression.

e—Preparation of Methods for Compensating Labor: With the four items above carefully arranged, it becomes comparatively easy to outline the best rates, premium and bonus methods readily adjustable to business conditions.

f—Maintaining Buildings and Equipment: If buildings and equipment are maintained to the highest degree of efficiency during strenuous times, oftentimes during a period of depression the expense involved can be eliminated, provided that this depression does not last too long, but it should not be carried to the point where the property has run down too far and requires a large amount of time and money to bring back to a proper stage.

g—Accessible Supply of Raw Materials: If a factory is remote from the supply and transportation companies and the latter are slow in making deliveries, it is quite necessary to carry a large amount of reserve raw materials in stock. To those that are near supply points, however, it is possible to reduce the amount of materials carried to a minimum and buy on short notice such materials as are required for plant operation.

The six items above mentioned, if carried to reasonable perfection, place a factory in condition of preparedness and the maximum amount of *kinetic energy* is available in an organization, leaving the question of materials on which the work is to be performed to complete the problem.

Stock on Hand: Having decided on readjustment of duties and schedule of working hours, rates to be paid and reduction in working force, the problem of turning quick assets of the business into ready money is a much more difficult one. Shrinkage in values of the natural products, such as pig iron, copper, tin, leather, zinc, etc., are such as to make wholesale sacrifices in prices almost impossible unless this shrinkage be offset by reduction in overhead and labor charges.

Articles showing least shrinkage in materials costs should be pushed and sold as rapidly as possible unless there is an abnormal profit on articles where materials show a greater shrinkage. All doubtful stock should be sold as scrap and turned into cash. Work in process should be finished and shipped at once, beginning with that which has the least labor to complete and working down to orders just started. Profit and ability of purchaser to pay promptly in cash should also guide in this.

Efforts should be made to get business of some kind to fill your plant, even if it is a little out of the regular line and somewhat special. With an oversold product and output, special work is not wanted, but with an output undersold to point of no profit or actual financial loss, special work will help absorb the overhead; further, if we expect to obtain foreign trade, we must furnish what they want and not what we think they ought to have. To accomplish this, it is quite necessary to have accurate records of costs and selling prices and a curve should be plotted showing how far reductions in price can be carried, bearing in mind that when overhead has been absorbed for the period of depression, gross profit turns to net, or, if it is impossible to do this, look at the curve with the idea of reducing overhead to correspond to reduction in business so you will break even or with a minimum loss. See the curve in Vol. 34, of Transactions of The American Society of Mechanical Engineers, page 1193.

Purchasing: There is no doubt but that a good purchasing agent saves his salary directly or indirectly, but in the case of the average-sized plant, where the volume of business does not warrant a purchasing agent, such plants could obtain the benefits of wholesale purchasing and keep in touch with the market by combining and hiring one good man to purchase all supplies and materials. The same applies to stock-keeping methods and stock handling.

Some, if not all, would say that this is impossible. True it is if that is the mental attitude, but, from an

economical and business standpoint, it is not, and would compel the training of sidesteppers who are evading their real responsibilities, to use more care and energy in their work and eliminate what is termed "shop politics" in organization. Truth and facts can be dodged for a while, but in the long run they will corner the dodger.

If the rate of production of all raw materials for manufacture could be brought to an even basis, either by arrangement or a fixed valuation basis, accumulation of stock on hand of raw materials, work in process or finished, that have accumulated with copper at 16 cents would not shrink in value $33\frac{1}{3}$ per cent when the price of copper dropped to $11\frac{1}{2}$ cents.

If our banking systems at large were more favorably disposed towards, or valuations fixed, these speculative losses and hardships would be eliminated and it would be unnecessary for individual manufacturers to carry so much raw stock. If materials were handled the same as money and distributed from territorial storehouses as requirements demanded, this burden would be equalized and carry with it a much more stable condition of market.

This has practically been done with steel. Why should it not be done with cotton, wool, copper, tin, zinc, lead, etc? It could be done if sound and broad business methods were substituted for the speculative craze of the individual who lives by his wits at the expense of some loser, and these conditions would become more stable.

Engineering Service: Many firms have an engineering organization for the supervision of power and plant work and the design and construction of buildings. Where operations are on a large scale this is undoubtedly the most convenient method, but not always the most economical, as there is a tendency towards extravagances and oftentimes the buildings cost much more than to have this work done by an engineer with much broader experience.

In times of depression a number of factories could get together and retain an engineer for much less than their organization is costing even though the per diem charge for work is greater, but they would be receiving a broader and more efficient service. There are very many shrewd business concerns in this city that do this and their total bills for a year amount to about half what the engineering organization is costing companies doing less business.

Lessons to be Learned:

1st: That the world is growing smaller;

2nd: That nations are more interdependent for internal financial and industrial prosperity;

3rd: The more civilization advances, the more nations coöperate in this advance;

4th: The lessons of thoroughness and preparedness are driven home;

5th: That this country is deficient in merchant marine;

6th: That shipping and banking facilities with countries which are used as a basis for the Monroe Doctrine, are controlled by the English, French and the German;

7th: That our factories are not prepared to meet the demands of trade for such countries;

8th: That the mental attitude of taking what is made "or leave it," must be changed if we expect to obtain and hold the trade of other American nations;

9th: That whatever the outcome of this war may be, it will be the engineering of the past forty years that develops the successful nation.

In prosperous times we go on in the even tenor of our ways and live our own lives as to personal and business expenditures, some saving systematically, others always living up to and beyond their income. Conveniences and luxuries which appear as necessities when the income account is liberal, appear as extravagances when the income account is suddenly reduced. The platitudes and complaints of our troubles in prosperous times are loud and numerous, but let depression come on apace and we become meek and chastened, thankful for small favors and more content with our lot and sorry for those who are infinitely worse off than we are.

So panics and depressions have their good points in at least giving us a chance to look around and see how much we can get along without, to inspire economies and less wasteful habits, to allow the physical and nervous system a diversion and rest, to make us more thankful for what we have, and, last but not least, more thoughtful and considerate towards others, thus building up character to a higher and nobler plane.

DISCUSSION

William Kent: After the Civil War it was thought there would be a great depression in this country owing to the discharge of so many men engaged in the activities of war, and putting them into channels of business. But they went back to work again and produced wealth faster than it had ever been produced before. Then followed an era of speculation and of rapid railroad building. Suddenly, in 1873, like a bolt from the blue, came the failure of Jay Cooke & Co. and the long five-year period of depression set in. We were paying $1.75 for common labor at that time in New Jersey, and inside of one year the same men were glad to get 87 cents a day.

The first thing that happened when the panic set in was to throw men out of employment, and the second thing was to put those men at work at 87 cents a day. The depression lasted five or six years. It lasted so long that people got accustomed to it and thought it was a normal thing. In July, 1879, I went into the steel business, when we were sell-

ing pig iron at $14 a ton. Then suddenly people woke up to the fact that the depression was over, that the country was short of pig iron, and the boom of 1879 was started. The same steel billets that I sold in July for $60 per ton I sold the following January at $110. In July we were selling pig iron at $14, and in January at $40 a ton. If we do not look out, we will get caught the same way again.

In 1893 we had another panic, followed by another five years of depression. As to what we should do in times of depression, let me say that after the panic of 1893 I visited the Baldwin Locomotive Works, and at that time the normal payroll was about 8,000 men. But then they had only about 800 men at work, one-tenth of the normal payroll, and the works were whitewashed and looked like a cemetery. They had reserve capital, so could wait patiently for better times.

During the panic of 1907, one of the smaller ones, when most people were pretty blue, I met one of the leading manufacturers of machine tools in New York, and asked him if he felt alarmed over the business prospect. He replied: "Mr. Kent, I never sell the United States of America short." I visited his big machine works and found them fairly busy. I asked the superintendent, "Are you doing all this work on orders?" "No," said he, "we are working on stock. There is a quarter of million dollars worth of goods piled up there at the end of the building. It will all sell at good prices in a year or so." And it did. That is the kind of courage we want now. We must not shut down production if it can possibly be helped. The danger is that the present depression will be followed by a sudden boom, and carry prices too high if we have not got stock on hand to meet the sudden rush which follows the panic.

I had occasion to write an article on pig iron two or three months before the panic of 1907, when pig iron had dropped from $25 a ton to $24; and people began to wonder whether it was not going to rise. I said that $25 is a danger signal, and pig iron will not rise again until it goes to $17 a ton. The editorial department thought I was crazy, and they were not going to publish the article; but they finally published it, and pig iron went down to $15 before it started to recover. When pig iron is $25 a ton, it must go down to $15. And when pig iron is $10 a ton it must go up to $15 or $20 at least.

Our farmers are doing very well, and people are wearing out shoes and clothes all the time, and they will need more when the present ones are worn out. The general business of this country, the production and consumption of foods and cars and building railroads and houses should go on; things are being worn out and they must be replaced. If we do not arrange to replace them soon, we will have to replace them later, and at higher cost. That is the boom period of unduly high prices. Begin to replace those things now.

In regard to this banking trouble, I am in harmony with what Mr. Waldron said. I think one of the troubles of this country is that the bankers and financiers have not yet learned the true principles of finance. The psychological condition President Wilson spoke of, is an absolute fact. Nervous prostration is nothing but nerves; but it is a serious condition that throws the whole system out of order.

Why can't we get money? Go back to the Civil War, when the question was, how could that tremendous war be financed when everybody was scared and the bankers were locking up money. The Secretary of the Treasury went to Wall Street, and the Wall Street bankers named their terms for a loan, and they said that was their ultimatum. The Secretary of the Treasury said: "Gentlemen, it is not the bankers of the nation that make ultimatums. It is the Government of the United States that makes ultimatums. And if you do not make this loan we will issue money, emergency currency, so much that it will take a basketful of it to buy a breakfast." And the Government issued the greenbacks. Finally it struck the bankers that they had gotten in wrong and they were glad to buy the Government's 7-30 bonds. Now the bankers are learning something. They take out clearing house certificates and emergency currency to tide them over the time of trouble; but yet they say "it is inflation, and the people will get extravagant." The people do not get extravagant in panic times, when this emergency currency is being issued, but in times of inflation following good times, when credit is good; and there is no reason why we should not have emergency currency to tide us over panics or periods of depression. I believe the bankers are all wrong with this whole idea of holding tight to a twenty-five per cent reserve during panic times. It is all right under ordinary conditions to have a twenty-five per cent reserve. If you engineers build a reservoir for supplying a city with water, you would not expect the city government to pass a resolution that twenty-five per cent of that water must always be kept in the reservoir, and that we could not use water when it got down to the twenty-five per cent level, for when a big fire or a long drought comes we will draw water until the reservoir is empty, if necessary. Why do we want to keep a reserve in the banks? "Because the law says we must," is what the banker replies; "if we do not, some State official will come down on us for not having that much reserve." "What is the reserve for?" we ask the banker. "We must have the reserve there," he replies. "What is it for?" we ask. "It is to have a reserve."

It is a nice thing to have reserve money in your pockets. Suppose you say to yourself that you will never have less than twenty dollars in your pocketbook. What good would that twenty dollars do your pocketbook, if, when you needed it, you did not use it? The reason for the reserve is for the purpose of having the money when you need it to spend. But the bankers say, "It is a terrible thing to loan money on copper and cotton," as was suggested to them. I say, "Why not loan on copper and cotton just as well as you loan on gold? Suppose a bank would loan on copper certificates say at 5 cents a pound. Copper never sold below 10 cents a pound, so it would be perfectly safe to loan money on copper at 5 cents a pound and then issue emergency currency, and have it carry a discount of one per cent a month, so that it would not be held longer than was absolutely necessary. That would make twelve per cent a year." "That is terrible, that one per cent a month interest," they say. "But," I reply, "it would tide you over a month or two or three months of trouble." So nobody would hold that money for a year, as it would decrease in value at the rate of one per cent a month.

We have heard about the need of elastic currency for the last ten years. We are going to have the reserve banks; that will help us. Very good. We have gone that far, and some day we will get a more sensible set of ideas about these

emergency issues, and these United States can be carried on in periods of depression without any trouble or worry whatever. That same banker said, "We cannot loan money on collateral, because we haven't got the money. We have to protect our reserve." I said, "Where is all the money now? Is it hoarded up?" He said, "Yes; it is hoarded. Thousands of people are hanging on to their money."

A man told me the other day, "If you have any money in the bank, draw it out." I said, "If you have any money, put it in the bank and let the banker loan it out and get business started." I said, "If you are going to buy a suit of clothes next month, go and order it now; that will put the tailor to work. If you are going to build a house next year, start on it now. That will put a lot of men at work. If you have any debts and can raise the money, go and pay them off. If you owe a man a dollar, pay it to him, and it will float around and pay other men's debts. We want stimulation, and people putting the money in the banks and the banks being as liberal as possible, instead of as stingy as possible." That will tide us over this emergency. That is what should be done.

SELBY HAAR: Referring to one point of Mr. Waldron's conclusions, to the effect that it will be rather difficult for us to capture the trade of South America, I believe it can almost be stated as an axiom that our foreign trade will be the more profitable to us, the more closely we can adhere to standard goods, which are manufactured in quantities. At any rate, it should be most nearly true in the machinery trade which I have particularly in mind at present. We differ from all other manufacturing nations in that workmen's wages are high here, in consequence of which our standard machine is designed to reduce the labor cost of the article produced by the machine either by the principles according to which it is constructed or the attachments with which it is fitted. Our competitors, however, have not considered it necessary to manufacture machines for their own use which are so sparing of the attendant's labor, and for that reason they have developed lines of machinery of minimum manufacturing cost. We are seeking trade in South America and other countries which industrially are not as highly developed as we are and where labor is cheap, a fact that favors our competitors, as it weakens our chief argument in justification of the higher price of our goods. Moreover, since the standard article of the European manufacturer more nearly meets the requirements of foreign trade than ours does, our competitors can adapt their machines to meet the special conditions of different countries more cheaply than we can. Thus the argument of purchase price is likely to be against us.

To overcome these handicaps, let us, if necessary, offer new lines of machinery especially for foreign trade, utilizing such principles of operation and attachments as are indicated by a thorough study of the actual conditions of use. We cannot expect the South American or the Asiatic to conduct his business as we do ours, but with our manufacturing experience and inventive genius we can help him to carry on business in his own way more successfully, and in this competition of brains we can hold our own.

FREDERICK A. WALDRON: In regard to the remarks of the last speaker, Mr. Haar (I will pass Mr. Kent's remarks, for I agree with him) it brings home to me an experience I had about a month ago. While what he says in regard to labor-saving, price, etc., the cheapness of labor in South America and other countries is all true, yet their unit cost of labor is higher. A gentleman came into our office five weeks ago in an indignant frame of mind. He came to the United States with $500,000 to purchase supplies (not machinery), such as nails, steel pipe, etc. He went to one concern, I think the largest in this country in its line, and asked for a quotation on steel-wire nails. The English practice is different from ours, as to the length of nail and weight of package. They require 112 pounds, while our standard package is 100 pounds. This large company would furnish them at a price; he also went to five other corporations running at forty or fifty per cent capacity, and asked them to furnish these nails of a given length put up in 112 pound packages. They replied, "We are very sorry, we cannot take the order; we don't make them that size, and we pack in 100 pound packages." Is not this high treason to American industries?

The same gentleman wanted steel tubes, wrought iron pipe size in 18-foot lengths. Receiving the following reply: "No, we cannot furnish unless you take it in 20-foot lengths," he replied, "Well, I will take them in two 10-foot lengths." They said, "No, you will have to take it as we make it or leave it."

Now, if tales of that kind get abroad, the effect is very harmful.

RECENT DEVELOPMENTS IN THE MANUFACTURE OF THE DIESEL ENGINE

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Member of the Society

It is my intention to emphasize fully the importance of a careful study of the engineering principles in general involved in the construction of oil engines of the Diesel type. It is a well-known fact that, compared with what has been accomplished with this prime mover in other countries, the United States has remained far behind, although conditions are in a large part of this country ideal for its extensive use. Aside from a number of other unfortunate circumstances, this condition is primarily due to a lack of appreciation of sound engineering practice.

There is hardly a problem that commands the attention of engineers at the present time more than that of the Diesel engine, which in certain fields at least, is giving an entirely new aspect to the manufacture of power machinery and to power-house engineering as well as to the commercial use of power. The importance of this problem is emphasized by the typical American aggressiveness with which the manufacture of this prime mover has lately been taken up since the expiration of the principal Diesel patents. If conscientiously pursued, with careful consideration of the most minute details, there is every reason to believe that this new enterprise will develop into one of the most stable industries. Signs are beginning to appear, however, indicating that this is not always being done. Merely for the sake of cheapness, practices have in some cases been adopted which, being evidently unconditionally taken over from gas engine and even steam engine experience, are of more than questionable merit.

The Diesel engine works under a maximum pressure of from 450 to 470 lb. per sq. in.; this is only 15 to 20 per cent higher than what is customary in gas engine practice. As far as control of the resulting strains in the various engine parts is concerned, no more difficult problems would, therefore, present themselves than in gas engine design. Unlike in the gas engine, however, it is imperative with the Diesel engine that this maximum pressure be attained with compression alone. Extreme accuracy of fits as well as alignment of the various engine parts must therefore be one of the first requirements in Diesel engine construction. This is not, as might at first appear, merely a shop question; the highest standard of workmanship cannot prevent rapid deterioration if unsuitable materials are used or features of design resorted to that result in excessive or unfavorable strains. Strength computations are only one part of the designer's work; a more important task is to study and if possible determine elastic deformations and their possible effect upon co-related parts. It is here where the designer's skill and experience manifests itself; by judicious distribution of material or form of constructive elements these deformations can be greatly reduced and transmitted in such a way as not to affect vital points of the engine. The unusual amount of painstaking work involved in investigations of this nature is well repaid by the satisfaction and insurance of having produced an engine that will meet the most exacting requirements. An engine built with such care will be as reliable as a steam engine and considerably simpler than the apparatus of a steam plant and the operator will be unaware of the high temperatures or pressures under which it works. In view of past experiences, this statement may sound Utopian to American engineers; nevertheless it is being proved daily and accounts for the fact that the aggregate horse-power of Diesel engines in operation today in European countries approaches the one and one-half million mark.

We are in the fortunate position of being able to draw from the wealth of information and experience accumulated during the last ten years in all these Diesel engine installations under the most varying conditions. This experience manifests itself in certain typical forms of constructional elements which have been found to give the best security for continuous service, even under adverse conditions. Information of this nature is accessible to every engineer through the technical press and I cannot but urgently plead for its careful study. By this, I do not wish to be understood to advocate blindly following practices which have been developed by one or two leading European concerns and adopted since then with very few modifications by later manufacturers. The cost of labor and its relation to the cost of raw materials are so different here from what they are abroad, that they invite certain departures from European practice. The ultimate aim, however, must be always a product which is first of all reliable; we must endeavor to incorporate those features which make for long life, not only under intermittent periods of operation, but under requirements such as have to be met with in industrial installations with as high as 144 operating hours per week.

As an example to illustrate this point, Fig. 1 shows a form of adjustable bearing which to many engineers

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still represents the ne-plus-ultra of mechanical perfection. With the pressures acting mostly downwards, the idea is to take up any wear in the lower box B by drawing up wedge W. Considering the fact that a slight clearance c must be maintained between shaft or pin and bearing to allow for lubricating oil, it can readily be seen that even under very best conditions, box B is always loose or floating between the moving shaft above and the wedge underneath it. That the latter, with its varying position according to adjustment and duty of transmitting all the forces acting upon box B, is not an ideal support for a bearing box, is quite evident. Utter lack of rigidity in the very direction where it is most required is therefore the first criticism of this construction.

An equally bad feature is the uncertainty of effective lubrication. Owing to the gap g between the two box halves which, of course, is necessary to facilitate adjustment, a comparatively low bearing pressure, combined with the rotation or oscillations at the bearing surface is required to reduce the thickness of the oil film sufficiently to cause excessive wear. A third drawback, which applies to a great number of modifications of this form of bearing, is the danger of shifting in regard to the shaft or pin axis. This is brought about by the lack of adequate mechanical means and therefore impossibility to maintain absolutely with any degree of certainty true alignment, either in operation or while adjustments on the wedge are being made; an error of only a very few thousandths of an inch can cause disastrous results. In view of these possibilities, the use of any form of wedge adjusted bearings, either as crank shaft bearings or crank-pin and piston-pin boxes, is to be condemned; experience even on gas engines has shown that they lack all the essential features that insure reliability in continuous operation and this will to an even greater extent be true in Diesel engine practice.

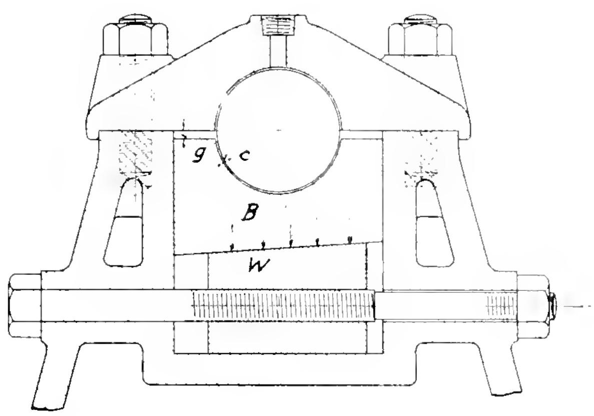


Fig. 1 A Generally used form of Adjustable Bearing

Fig. 2 shows the form of bearing which has fulfilled all requirements of continuous service in a most successful manner. Rigidity is insured by the bearing shells being fitted over their whole circumference directly into the main structure without any intermediate parts. Furthermore, they are drawn down tight on each other by means of the bearing cap, usually with shims s between the joint, so that a continuous oil film of ample thickness can be maintained over the whole bearing surface. The pin or shaft is thus actually kept floating on oil so that wear will be reduced to a minimum. It is even conceivable that with clean lubricating oil and a proper lubricating system, wear might be entirely eliminated. Cases are known where Diesel engine main bearings of this form still showed original scraper marks after two years of operation. It is due to these features that accuracy and maintenance of alignment are insured to a degree not obtainable with any other form of bearing known today.

Vertical, moderate-speed four-cycle engines, with rotative speeds ranging from 150 to 200 r.p.m., and piston speeds from 650 to 750 ft. per min. are considered here as the one type which experience has proved

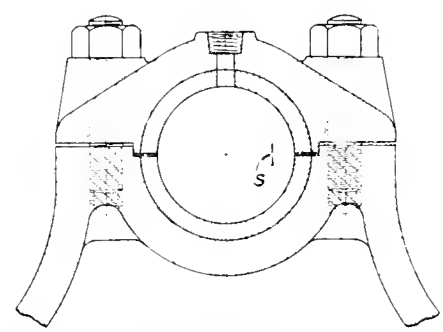


Fig. 2 A form of Rigid Bearing that satisfies Diesel Engine Requirements

to be more than any other adapted to meet successfully general industrial conditions in sizes up to 175 to 200 h.p. per cylinder. For very small sizes or installations where the load factor is low, two of the leading German makers have, within the last few years, developed a line of horizontal engines of the Diesel type. This form is somewhat lower in first cost and therefore better adapted for conditions where the fixed charges have to be distributed over comparatively few operating hours. Under these conditions, the inherent disadvantages of horizontal engines probably will not manifest themselves sufficiently to cause excessive maintenance expenses, although naturally experience extending over sufficiently long periods to furnish conclusive data is at the present time still lacking. The two concerns referred to above, although being the largest manufacturers of horizontal engines, have at the same time a far larger output in vertical units.

As regards vertical engines, distinction must be made again between the moderate-speed and the high-speed type, running anywhere from 200 to 400 r.p.m., with piston speeds ranging from 800 to 900 ft. per min. and more. These were brought out lately to meet

a demand for compact and light prime movers to be used as auxiliaries on board ships or as a standby for lighting, power and pumping plants, where space is limited. Unfortunately not enough information is generally available whereby a relation between most favorable operating conditions and rotative or piston speeds can be definitely established, but this much is known, however, that high piston speeds are decidedly detrimental to continuous satisfactory operation. It is only under conditions such as rather infrequent and short operating periods, therefore, that the high-speed engines can give a fairly good account of themselves and even then their depreciation is quite rapid.

The characteristic features of the Diesel cycle of operation cannot be more quickly grasped than by reference to the comparative indicator diagrams, Fig. 3, of a Diesel engine, a gas engine and a steam engine, all

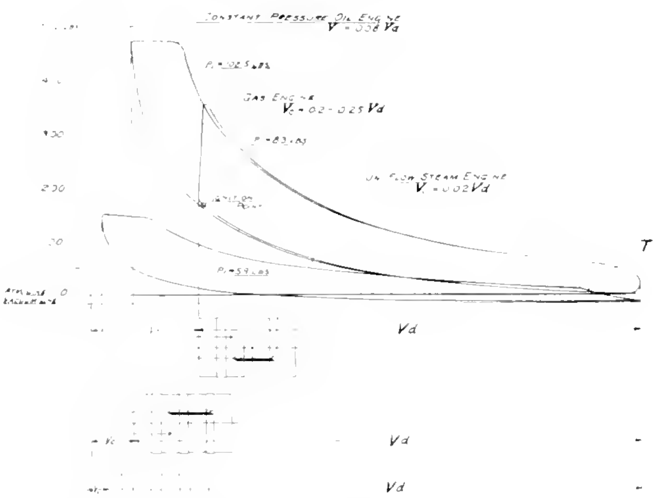


FIG. 3 COMPARATIVE INDICATOR DIAGRAMS OF DIESEL ENGINES, GAS ENGINES AND UNIFLOW STEAM ENGINES

three having the same cylinder volume. The steam engine diagram is characteristic of the uniflow engine, a form which permits the utilization of the whole pressure range of the steam in one cylinder in the most ideal manner. The similarity of this diagram to that of the Diesel engine is quite striking, except for the toe T, caused by the uncovering of the exhaust ports of the steam engine piston. The Diesel engine diagram shown is that of a four-cycle engine; in the card of a two-cycle engine, a similar toe would be apparent. The maximum pressures, while, of course, about three times higher in the Diesel engine, are in both engines obtained very gradually by compression alone, while in the gas engine the pressure at the end of the compression stroke is only about 160 lb., followed by a practically instantaneous pressure increase to 360 lb., or about 125 per cent. It can be seen from this that while the maximum pressure reached in the Diesel engine is about 15 to 20 per cent higher, the gas engine nevertheless works under less favorable conditions. In actual practice, this manifests itself in a distinct pound in the gas engine, which is not noticeable in the Diesel engine. Due to the higher compression, the clearance volume of the Diesel engine is about 8 per cent of the displacement volume, compared with 20 to 25 per cent in the gas engine. In the uniflow engine, with the steam exhausting into the condenser under a very low vacuum, the clearance volume is only 2 per cent of the displacement volume, although not all of the latter is available for compression, as the exhaust ports extend usually over about 8 per cent of the piston stroke.

Since Fig. 3 shows the diagram of the three types of prime movers over the same cylinder volume (at the end of the expansion stroke), it forms a ready means of comparison in regard to their specific work capacity. With the uniflow steam engine highest and the gas engine lowest, the proportions are about

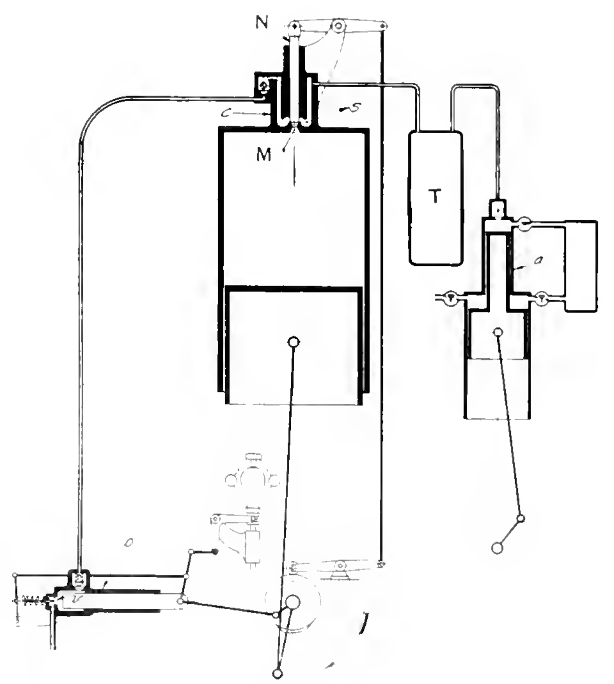


FIG. 4 DIAGRAM OF WORKING ELEMENTS OF THE DIESEL ENGINE

1.85 : 1.35 : 1.0. The four-cycle Diesel engine with its one working stroke against the two of the steam engine, is, therefore, a fairly close second, while a two-cycle Diesel engine, although its mean effective pressure is considerably lower than that of a four-cycle, leads the steam engine by about 18 per cent. This superiority of the two-cycle engine over the four-cycle in regard to capacity is quite generally understood and accounts for a rather widespread belief that the Diesel engine of the future will be of the two-cycle type. Unfortunately, however, this very fact of double the power strokes and double the heat influx through a given cylinder surface, introduces physical and mechanical problems of a complexity unknown in four-cycle engine work. In a two-cycle engine, the heat to be transmitted through one square foot of cylinder

surface amounts to approximately 90,000 B.t.u. per hour, as compared with about 10,000 B.t.u. in a steam boiler. In a four-cycle engine cylinder of the same size, the corresponding figure is approximately 40,000 B.t.u., i.e., less than one-half owing to the higher economy over the two-cycle engine. The overheating of four-cycle engines, when working under heavy overloads for any length of time, may well give some idea of what is happening in the two-cycle cylinders. If to this is added the extremely high mean bearing pressure which is continuously acting in the same direction and thus aggravates the difficulty of lubrication, it is little wonder that the two-cycle Diesel engine has so far failed to fulfill most of its promises, except for large, slow speed, stationary units.

Owing to their high mean temperature, any strains of the reciprocating piston, even those resulting from the weight only, have proved detrimental and must be kept away from the cylinder walls. This can be accomplished only in a vertical cross-head type engine with water-cooled pistons and even then experience has amply proved that nothing but the longest possible intervals between "heat impulses," i. e., slow speeds, will guarantee its success. Such features cannot be incorporated in engines below about 200 h.p. per cylinder without increasing their cost to a prohibitive figure. It can safely be said, therefore, that for anything like steady daily service, the two-cycle Diesel engine of small or medium size is out of the question. The reluctance with which these facts are accepted by those not thoroughly versed in Diesel engine practice is shown by one or two types of two-cycle engines that are conspicuous by their cheapness as well as poor engineering features. The temporary advantage gained by the cheap first cost is in a short time wiped out by the heavy maintenance cost and involuntary shutdowns.

The high compression of the Diesel engine as shown in the diagram, Fig. 3, indicates that there must be a fundamental difference between its method of operation and that of other forms of internal combustion engines. With the latter, it is a well known fact that the danger of premature ignition of the gas and air mixture contained in the cylinder during the compression stroke, limits the maximum compression pressure to a value far below that obtained in Diesel engines. In the latter, pure air alone is compressed in the engine cylinder, which, of course, at once eliminates all danger of premature ignition. The fuel is not brought into contact with this highly compressed air until the end of the compression stroke. From this the need for entirely new mechanical means on the Diesel engine, as shown diagrammatically in Fig. 4, is apparent. Aside from the usual cylinder and piston with admission and exhaust valves, each Diesel engine requires an air compressor *a*, capable of compressing air to a pressure as high as 900 lb. per sq. in. These air compressors have at least two, preferably three, pressure stages with effective intercoolers between each stage, so as to keep the air temperatures always as low as possible. From the last stage, the air passes to a receiver *t*, which is continuously in open communication with space *s* of the fuel valve cage *c* on the engine cylinder. Fuel oil pump *o*, under control of the governor, periodically delivers a measured quantity of oil corresponding to the load on the engine, into space *s* of the fuel valve cage. This oil, it will be observed, must be delivered against the high pressure prevailing in space *s*, as will be referred to again. As soon as the fuel valve *n* opens, the high pressure air will blow the fuel from space *s* into

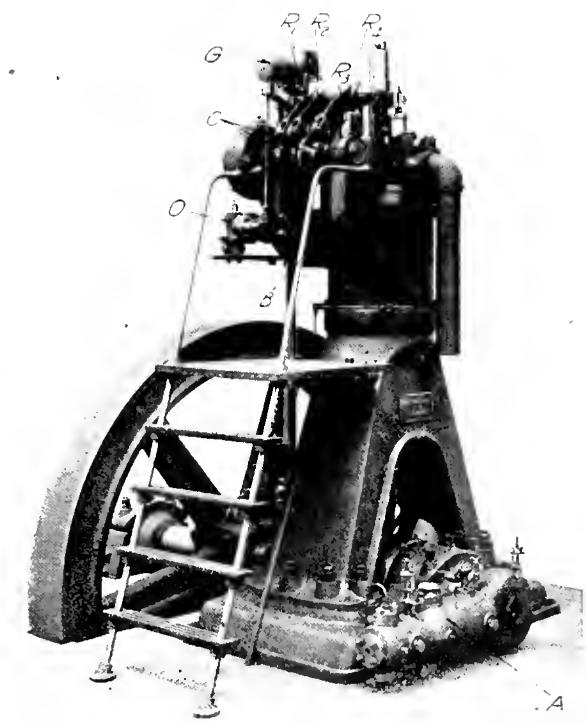


FIG. 5 AN EXAMPLE OF THE CONVENTIONAL TYPE OF VERTICAL FOUR-CYCLE DIESEL ENGINE

the engine cylinder where air has in the meantime been compressed high enough so that the resulting temperature will immediately ignite the fuel injected into it. This injection continues over about 10 per cent of the downward stroke of the engine piston in such a way that combustion of fuel takes place at approximately constant pressure (see indicator card, Fig. 3). The important function of the high pressure air compressor *a* can now be readily understood in that it furnishes the necessary medium to carry the liquid fuel into the engine cylinder against the high pressure prevailing therein; incidentally it also furnishes the air required to start the engine.

Fig. 5 shows an older form of the conventional type of vertical four-cycle Diesel engine, on which the arrangement of the principal parts just enumerated can

be clearly seen. The air compressor, *A*, is here mounted horizontally along the engine base-plate and driven directly from a side crank on the engine shaft and forms, therefore, an integral part of the engine; this is to-day the general practice on all modern Diesel engines, as it has been found to be by far the most effective arrangement. The vertical arrangement, as in Fig. 23, is, however, to-day given the preference, as it gives more satisfactory results and has, therefore, been adopted even for horizontal engines. The fuel oil pump, *o*, is mounted on the cam shaft bracket and is driven from the vertical shaft which transmits the motion from the crank shaft to the cam shaft. This same vertical shaft carries on its top the governor, *G*, which regulates the amount of oil to be furnished by pump *o*, although a somewhat simpler and neater arrangement for this governor is found on most of the latest forms of engines by placing it on the vertical shaft underneath the oil pump.

Fig. 5 gives also a good idea of valve gear arrangement. The cam shaft runs alongside the cylinder head and is supported on brackets *B* bolted to the engine frame, which permits the removal of the cylinder head without having to dismantle the cam shaft. With the cams *C* thus brought close to the valves in the cylinder head, the mechanism required to operate each valve reduces itself to a single rocker arm R_1, R_2, R_3 and R_4, and the absence of rods or any other intermediate parts thus insures maintenance of accuracy in the valve setting as well as quiet operation. As an additional insurance, some designers have lately completely enclosed the cam shaft in a continuous housing, whereby the cams and cam rollers can be thoroughly lubricated and dirt and dust kept away from them.

The accepted practice on all internal combustion engines for starting is compressed air, which suggests it-

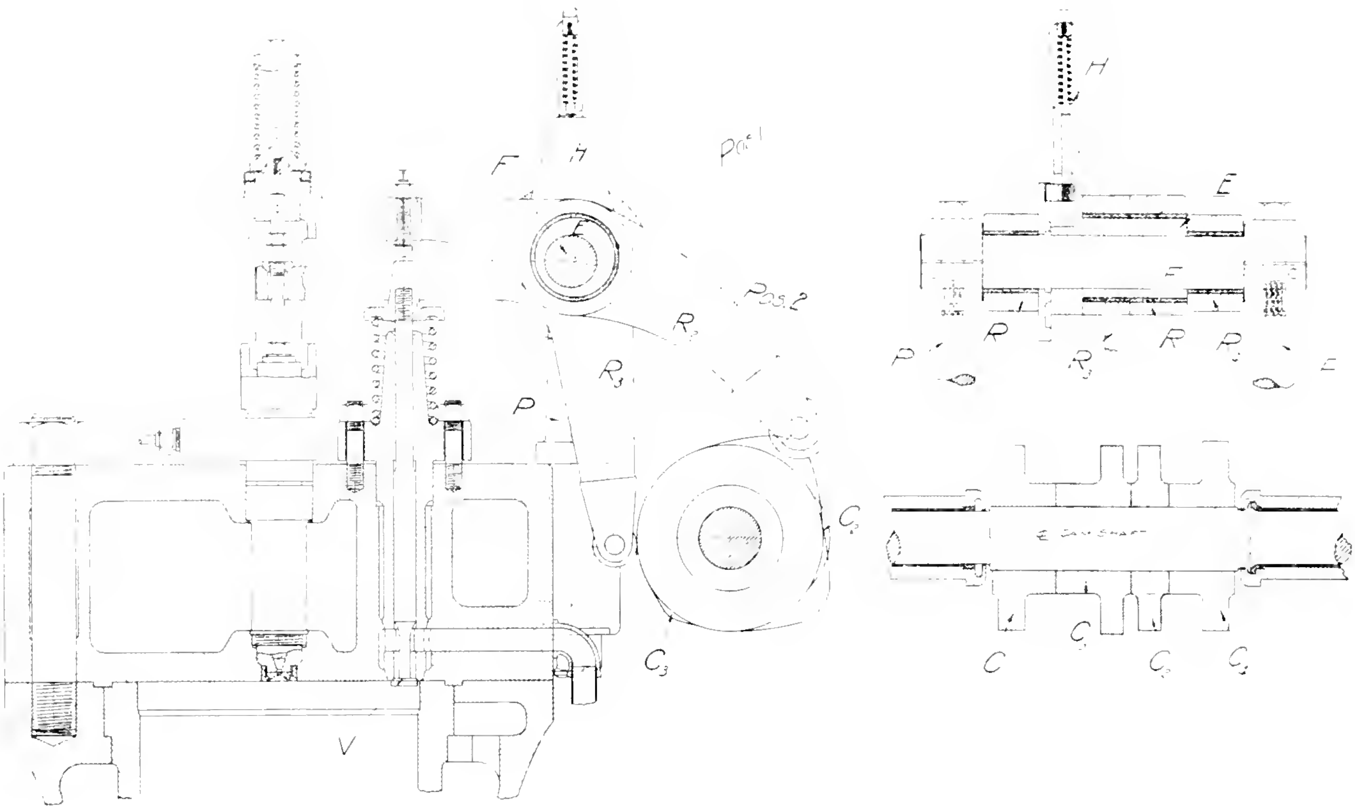


Fig. 6 Details of a form of Starting Mechanism commonly used in Diesel Engine Practice

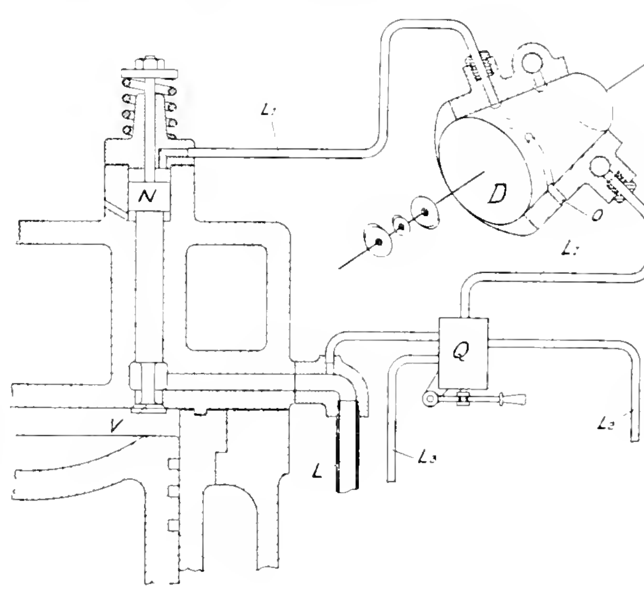


Fig. 7 A form of Apparatus used in Marine Practice for Operating the Starting Valve

self all the more on the Diesel engine on account of the use of the high-pressure air compressor. The fact that air of a pressure varying from 700 to 900 lb. per sq. in. is needed to inject the fuel into the engine cylinder naturally suggests the use of air of this same pressure for starting and this actually is the practice generally pursued in modern Diesel engines. One or two large seamless steel receivers of ample capacity for several starts each are to-day used on every engine, these being kept charged with air of from 700 to 800 lb. pressure.

In the first stages of Diesel engine development in Europe, this high pressure air system had often been criticised as dangerous; now, since thousands of installations have proved their safety to exceed that of steam boiler plants, owing to the absence of high temperatures and the small pipes used, it is accepted as the simplest and most reliable system for starting. Nevertheless, schemes are occasionally brought out in which the high-pressure air system has seemingly been done away with by replacing both injection and starting air receivers with one tank, which is kept charged with air of about 200 lb. pressure. In starting, the engine is operated with air of this lower pressure until a sufficiently high air pressure has been built up in the injection air line to permit the injection of fuel oil into the engine cylinder. The high-pressure air compressor as well as the high-pressure air line to the injection valves are, of course, retained with this arrangement, so that the mere elimination of the high-pressure air receivers means a very small gain in regard to safety. A very serious drawback is introduced, however, due to the resulting absence of reserve capacity of compressed air. If it takes about ten charges of compressed air to build up the injection air pressure, it can be seen readily that with an initial pressure of only 200 lb. very little air will be left for another start if the first attempt should fail. Furthermore, the absolute dependence upon every stroke of

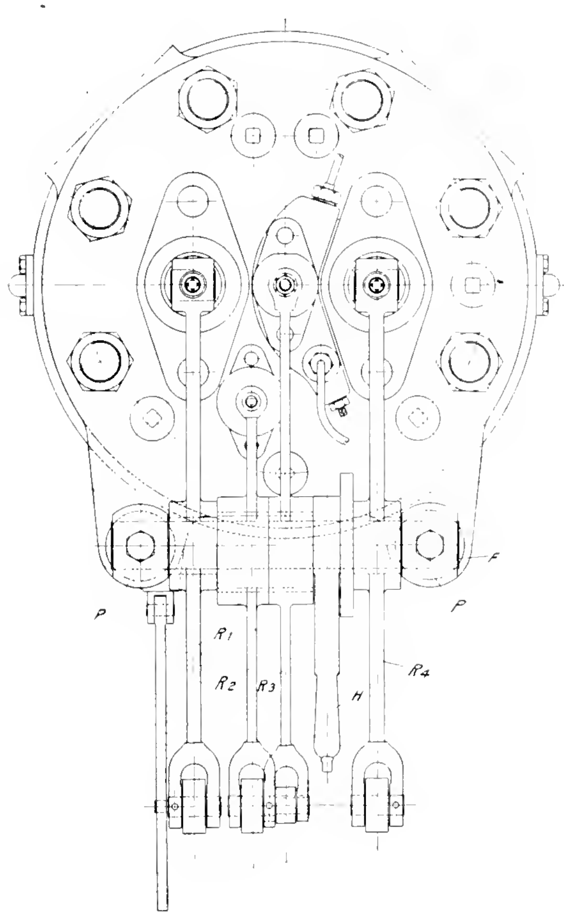


FIG. 8 PLAN VIEW OF THE VALVE GEAR SHOWN IN FIG. 6

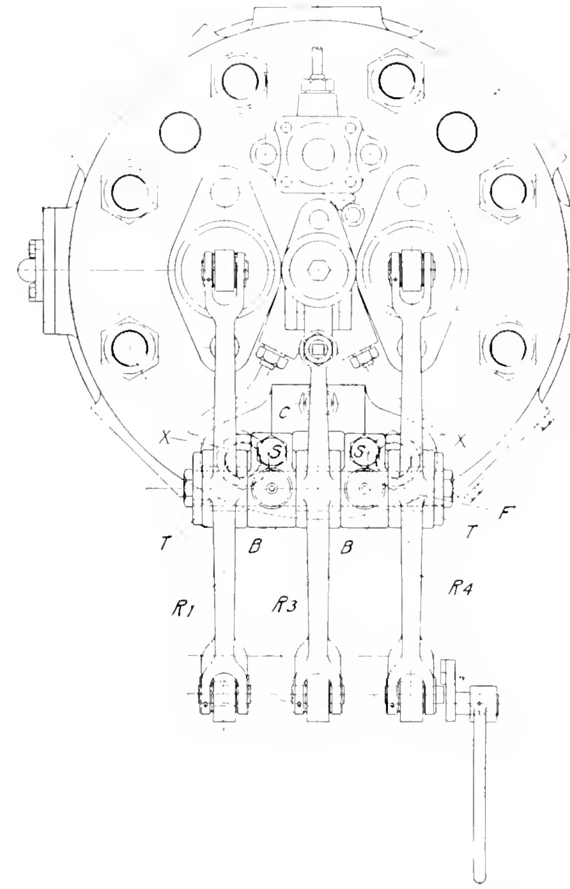


FIG. 9 A MODIFIED ARRANGEMENT OF THE VALVE GEAR TO FACILITATE REMOVAL OF ROCKER ARMS

the air compressor so as to prevent immediate reduction of the injection air pressure below that of the highly heated air in the engine cylinder, with resulting explosion in the injection valve cage and especially burning off of needle valves, does not greatly add to the reliability of this system.

The customary arrangement on the engine to facilitate starting consists of a valve V, Fig. 6, which is mechanically operated by means of rocker arm R_2, and this, as well as the injection valve rocker arm R_3, are both mounted on an eccentric E, which is provided with the handle H. With this handle in the running

position, as shown in full lines in Fig. 6, rocker arm R_2 is raised sufficiently to let its cam C_2 pass underneath it without operating valve V, while rocker arm R_1 is in its normal operating position. To start the engine, handle H is turned 90 degrees into position 2, when rocker arm R_1 is moved out of contact with its cam C_1, while R_2 now moves into operating position. With handle H in position 1, neither rocker arm is working and the engine is thereby stopped. Valve V is made a balanced valve by giving its stem the same diameter as the valve proper, thus permitting the starting air to be turned on without causing it to open.

Induced by the requirements of marine practice for which the system just described does not lend itself as readily on account of the frequent maneuvering, several schemes have lately been devised whereby the starting valve is operated pneumatically. This permits a considerable simplification of the whole valve gear which, with some modifications, is applicable to advantage on stationary engines as well. Fig. 7 represents schematically one such system which has given very good satisfaction. Mounted on the same shaft with the cams is the rotary distributor D which, by means of suitable passages, periodically connects a chamber over the starting valve first with branch L_1 of the starting air line and then to the atmosphere through O. Piston N on the starting valve stem is thus acted upon to operate valve V the same way as was formerly the case with the rocker arm R_2. This starting operation begins as soon as the quick-opening valve Q is moved to admit air from the main starting line L into the branch line L_1; valve Q is so arranged that the engine can be started either from the platform or engine room floor at will.

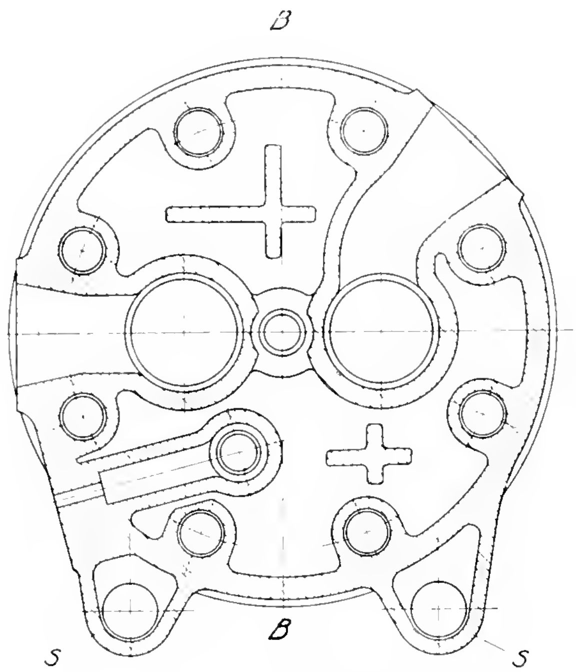


Fig. 10 Cross-section of Cylinder Head shown in Fig. 8

Here is an example where it has paid well to make a departure from conventional European practice. Aside from providing means for starting and stopping the engine either from the engine platform or engine room floor and thus eliminating one of the criticisms made against vertical engines, it has helped to considerably simplify the valve gear as Figs. 8 and 9 will show. Fig. 8 gives a top view of the valve gear shown in Fig. 6. R_1 is the rocker arm for the exhaust valve, R_2 that for the starting valve, R_3 for the injection valve and R_4 the one for the admission valve. All these, together with eccentric E and handle H, are mounted between the supporting posts P on fulcrum F (see also Fig. 6). It will be noticed that in order to remove any of the valves from the cylinder head the rocker arms with their fulcrum F must first be bodily lifted out of the supporting posts P. With the elimination of rocker arm R_2 and the handle H, a more convenient method of support could be adopted for the valve gear shown in Fig. 9. Here rocker arms R_1 and R_4 are mounted on the overhanging ends of fulcrum F, the latter being rigidly supported by the chair C between its two bosses B with the injection valve rocker arm R_3 in between them. Either rocker arm R_1 or R_4 can be easily withdrawn by taking off the end plate T, which permits quick removal of the admission or exhaust valve while the rest of the valve gear remains intact. Full access for removing the injection valve is obtained by loosening the two clamping bolts S in the chair C so that fulcrum F can be shifted lengthwise until rocker arm R_3 can be taken off. These modifications, although insignificant in themselves, are the simple short cuts which make proper supervision easy.

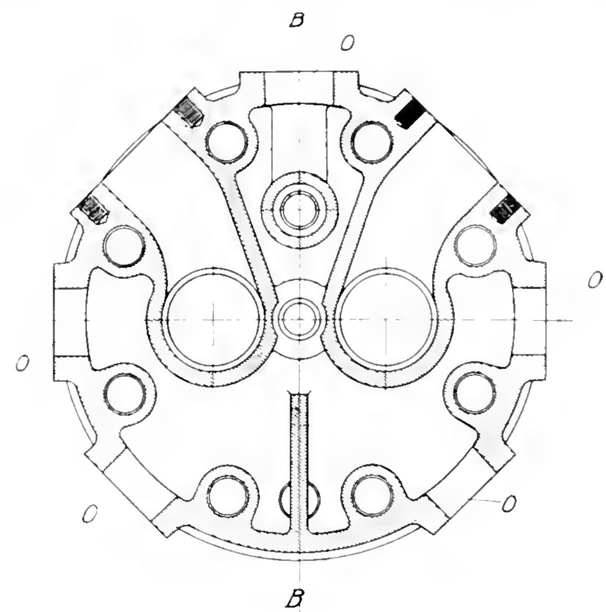


Fig. 11 Cross-section through a Cylinder Head of Symmetrical Design

Probably the most important, although least notice-

able, advantage resulting from this modified valve gear is the simple cylinder head construction. It is well known from gas-engine practice, that the cylinder head is one of the most delicate parts on the whole engine, and this is to a still greater measure true with Diesel engines where, owing to the higher pressures, although with temperatures slightly lower than in gas engines, extreme care must be paid to a suitable design. Aside from proper material which in itself requires considerable study, the first requirement is to obtain a casting which is as free from initial strains as possible. With our present knowledge very little can be done to determine these mathematically beforehand; the designer must here be guided by logical reasoning, based upon practical experience.

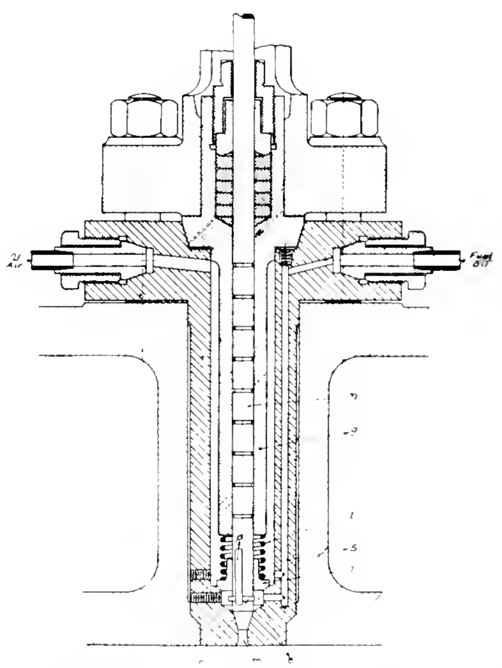


FIG. 12 TYPICAL FUEL ATOMIZER USED ON EUROPEAN DIESEL ENGINES

The cross-section through cylinder head shown in Fig. 10 is typical for the valve arrangement and valve gear shown in Fig. 8, but, although quite generally used, it can hardly be considered an ideal one. With the exhaust and admission passages running in different directions and the starting valve placed to one side of center line *B-B*, this cylinder head has no axis of symmetry; the unequal distribution of metal is likely to cause initial strains of widely varying magnitude at different points of the casting which cannot be entirely relieved by annealing. Under this condition, the additional and quite considerable, strains resulting from the high working temperatures and pressures in the engine cylinder may cause deformations (sometimes even rupture) which will seriously affect the life of the valves and impair the accuracy of their timing, particularly the closely fitted injection valves. It is evident that the overhanging lugs *S*, which support the valve gear posts *P* (see Fig. 8) transmit quite an appreciable bending moment upon the walls of the cylinder head, thus adding to the complexity of the case.

Considerably more freedom from all these influences is obtained with a cylinder head as shown in Fig. 11. The symmetrical distribution of the metal about the axis *B-B*, together with liberal hand holes *O*, are conducive to small initial strains and more uniform working strains, aside from offering the advantage of easier moulding. This arrangement is made possible by locating the air starting valve on center line *B-B*, away from the valve gear side. No bending strains are transmitted to this cylinder head since chair *C* (Fig. 9), supporting the valve gear, is mounted on the cylinder head and held down by the two studs *X*.

One of the most important parts of the Diesel engine

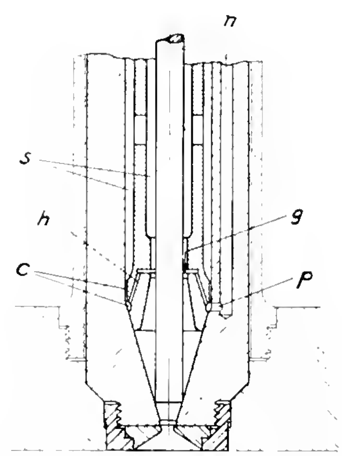


FIG. 13 ANOTHER WELL ESTABLISHED FORM OF ATOMIZER FOR VERTICAL ENGINES

is the fuel injection valve, which, as Fig. 9 shows, is arranged vertically in the center of the cylinder head. This has been found to be the most advantageous location and is one of the reasons why the vertical engine finds so much preference among Diesel engineers. With all the valves arranged vertically in the cylinder head, whereby wear on their guides is almost entirely eliminated and accurate seating at all times insured, a perfectly cylindrical and, therefore, most ideal combustion chamber is obtained. A similar form of combustion chamber can, of course, also be obtained on horizontal engines if the valves are placed horizontally; this, however, means resorting to a practice long ago discarded on gas engines after it was found to be inferior to the vertical valve arrangement.

The introduction of the fuel into the engine cylinder is one of the most intricate problems involved in Diesel engine design. This can be readily understood if it is remembered that on stationary engines of the type here considered, a period of only about 1/25 to 1/35 of a second is available gradually to inject the fuel, and at

the same time convert it from the liquid state into very minute particles which will have to be gasified and brought into intimate contact with the air necessary to sustain combustion. The usual means for accomplishing this is illustrated in Fig. 12, where the lower end of the needle valve guide g is provided with a series of perforated discs b, the holes in which straddle each other from plate to plate. Between injection periods the fuel oil is deposited on these discs where it will spread out and equally distribute itself all around the valve guide. When needle valve n opens, the high pressure air blast passing down through the holes in plates b will wipe the oil off from these comparatively large surfaces and carry it through longitudinal or spiral grooves p and nozzle m into the combus-

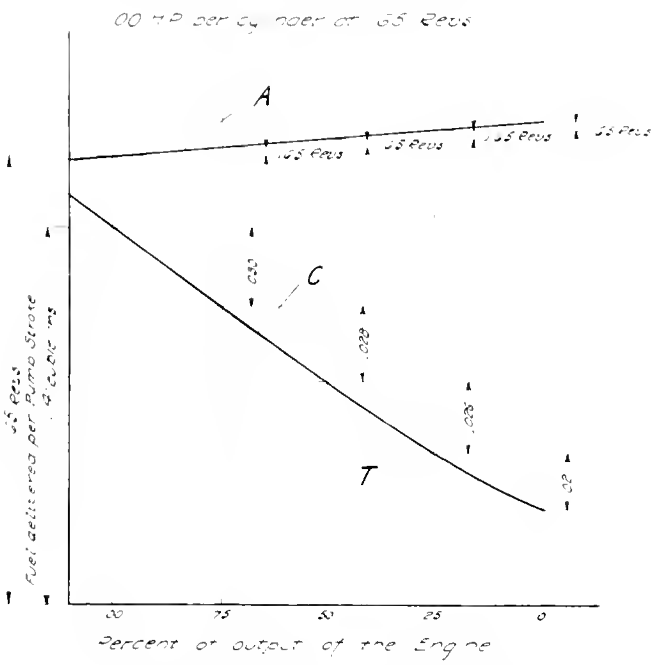


Fig. 14 Regulation Diagram of a 100 H.P. Diesel Engine

tion chamber; the artificial resistance thus introduced to retard the oil while the air passes over it at a high velocity, effectively disintegrates the liquid into a very fine spray.

Quite a number of modifications, all based upon the principle just explained, have lately come into existence for use with various fuels. Notable among these are the provisions made to insure the introduction of fuel into the combustion chamber with the very first particles of injection air, particularly with fuels having a very high flash point. Experience has taught that in connection with such oils the cooling effect of the injection air has a detrimental influence on quick and complete combustion which can only be eliminated with any degree of certainty by providing for immediate ignition of oil particles as soon as the injection valve opens. It is beyond the scope of this paper to attempt to cover this very interesting phase of Diesel engineering, especially since it is still decidedly in the development stage.

For completeness, however, reference will be made to another of the well-established forms of atomizers for vertical engines, the principle of which differs somewhat from the one described above. Oil is delivered through passage p, Fig. 13, partly filling annular space c as well as a series of holes h, while space s is as usual in connection with the injection air receiver. With the opening of needle valve n the flow of injection air will immediately cause a drop of pressure at g, thus gradually forcing the oil up through holes h into the stream of injection air passing down along valve n. It will be observed that in this atomizer also great care has been taken to insure equal distribution and thorough mixing of oil with the injection air.

While the injection valve provides the means whereby atomization and introduction of fuel into the engine cylinder are controlled, it is the function of the fuel pump to deposit the proper amount of fuel oil in the injection valve cage; upon the former depends the economy of the engine, while the latter affects the regularity of its operation. This is again a phase of Diesel engineering which requires extremely careful study on the part of the designers as the following consideration will show: Fig. 14 represents the regulation diagram of a 100 h.p. engine at a normal speed of 165 r.p.m. Any change of load will cause a change of speed and corresponding change of governor collar position, the ideal condition being where these changes are proportional to the load carried by the engine. This condition is represented by line A which, it will be observed, shows equal increments of speed changes and governor collar travels for equal load increments. Curve C shows the variation in the amount of oil to be delivered per pump stroke for these various load increments. At the normal load 0.141 cu. in. of oil are required per pump stroke; at three-quarter load this quantity is reduced by 0.030 cu. in., at one-half load by about 0.028 cu. in., etc., down to 0.021 cu. in. at no load. From this it follows that while the governor collar travels are constant for the same fractional load variations the changes in the capacity of the oil pump follow a different law. Considering the fact that the quantities to be pumped are extremely small and must, as we have seen, be delivered against the high pressure of the injection air, the care involved in a pump of suitable design can readily be appreciated.

Mention must here be made of the so-called "open injection nozzle" and its effect upon the pump design, which has lately been greatly exaggerated. The characteristic feature of the open injection nozzle consists of a small chamber or passage continuously in communication with the combustion chamber through the injection nozzle, the fuel oil being delivered into this chamber while the pressure in the engine cylinder is approximately atmospheric. By this expedient no appreciable back pressure has to be overcome by the pump in delivering its charge which, it is claimed, greatly simplifies its construction. It cannot be de-

nied that this is of some advantage inasmuch as a stuffing box on the plunger can be dispensed with. It is extremely questionable, however, whether this slight simplification of the pump compensates, especially in larger engines, for the indirect control of fuel injection with a valve which merely cuts off the injection air blast. To the author's knowledge no success has so far been had with the open nozzle arrangement on vertical engines.

Curve C of Fig. 14 incidentally shows the remarkably steady fuel consumption of the Diesel engine, which is almost proportionate to the engine load as a comparison with tangent T to curve C at the point of normal load indicates. In this respect the Diesel engine differs from any other prime mover known today and accounts for the fact that even at a small load factor its economy is singularly high. Moreover, this economy is maintained in continued operation since the automatic and complete control of the governor and absence of all auxiliaries entirely eliminates the personal element.

Three distinctly different methods of fuel oil pump regulation are known today:

1—Variable stroke of the pump plunger;

2—A mechanically operated by-pass valve by means of which more or less of the oil taken in during the suction stroke is returned to the suction chamber during the discharge stroke; and

3—Variation of the capacity of the pump chamber (variation of the clearance volume).

Typical forms of oil pumps constructed on the first method are shown diagrammatically in Figs. 15 to 18. In Fig. 15 the pump plunger is operated positively on the discharge stroke by means of a cam while on the return or suction stroke a spring keeps the plunger in contact with the receding cam until it is stopped by a governor-operated wedge which thus varies the suction stroke. This form of pump is unsuitable for work against heavy pressures as the friction of the plunger stuffing box could only be overcome by quite a heavy spring which from the time the plunger is forced against the wedge, would render the governor inoperative; on light loads this would happen during almost the complete turn of the cam so that regulation would be seriously affected. The same holds true of the pump shown in Fig. 16, where a shaft governor acts directly upon two eccentrics to shift one relative to the other and thereby change the stroke of the plunger. With a stuffing box sufficiently tight to pack the plunger against heavy pressures, as well as due to the pressures acting upon the plunger itself, the reaction upon the governor would frustrate all attempts of regulation. Both these forms of pumps are, therefore, only used in connection with open nozzle engines where low back pressure on the oil permits the elimination of a gland at the plunger.

Fig. 17 illustrates an attempt at adapting the variable stroke principle for high-pressure work; here the plunger is operated indirectly from a cam by means of a lever and a bell crank with a governor controlled roller interposed between them. As in Fig. 15, the discharge stroke only is positive, the return stroke

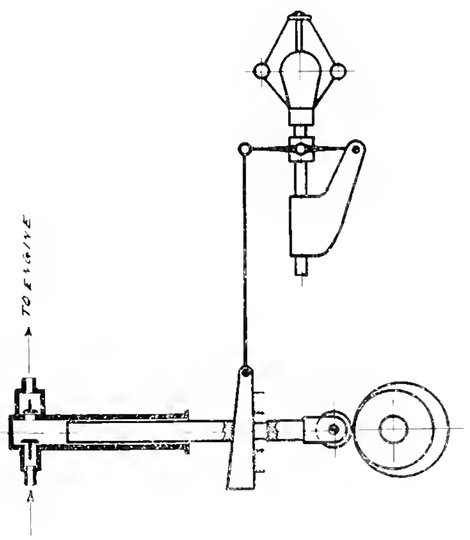


FIG. 15 METHOD OF GOVERNING BY CONTROLLING LENGTH OF SUCTION STROKE

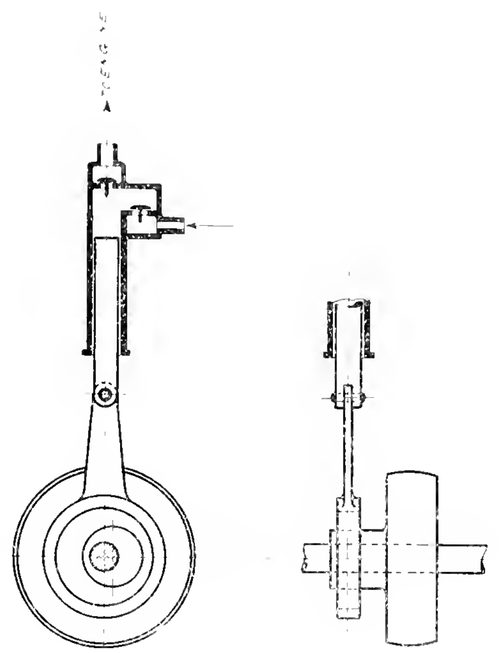


FIG. 16 GOVERNING BY ANOTHER METHOD OF CHANGING LENGTH OF SUCTION STROKE

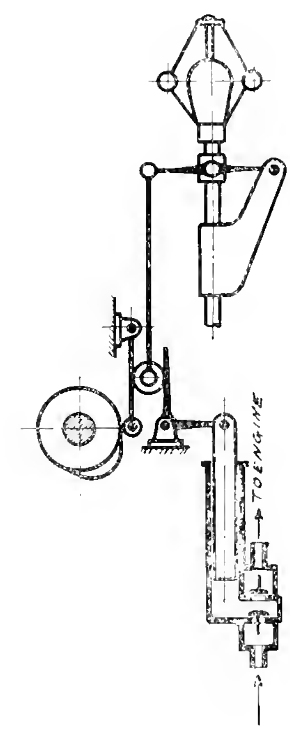


FIG. 17 A LEVER AND BELL CRANK MECHANISM FOR CHANGING STROKE

again being accomplished by means of a spring which in this case must be heavy enough to overcome the gland friction at the plunger. It is evident that in spite of the roller, excessive friction work can be easily imposed upon the governor if the gland at the plunger or the spring for actuating it is carelessly adjusted, and this form of pump, therefore, can hardly be considered satisfactory in all respects for accurate regulation.

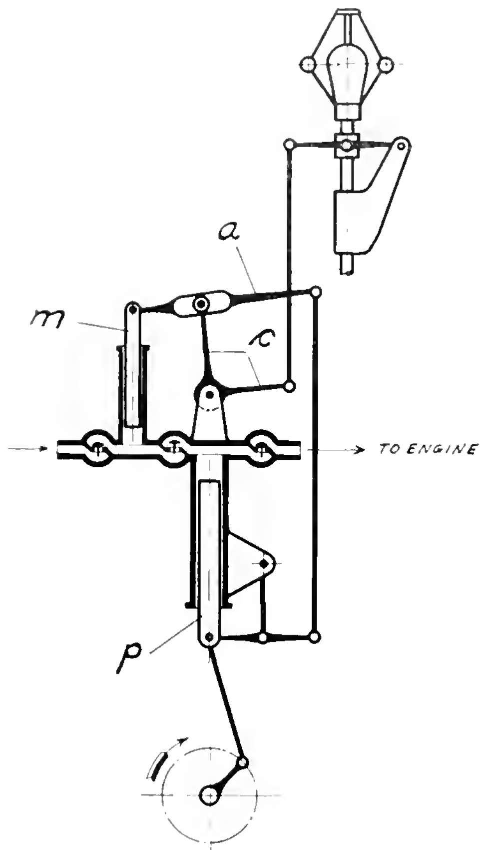


Fig. 18 Governing the use of two Pumps, one for Measuring and the other for Forcing

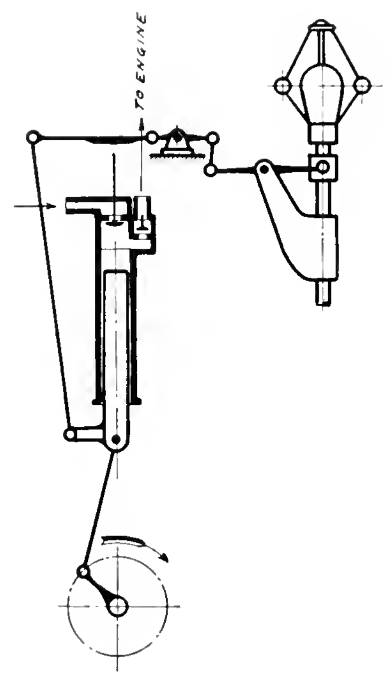


Fig. 19 Method of Governing by By-passing to Suction Chamber

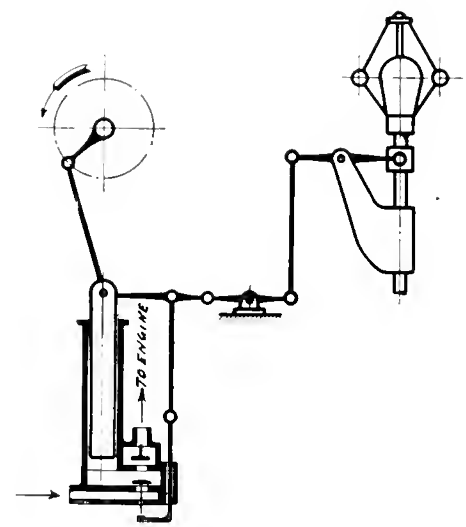


Fig. 20 Another form of Governing by By-passing to Suction Chamber

Fig. 18 illustrates the very interesting case where the process of measuring the oil and then forcing the measured quantity to the engine against the high pressure of the injection air is assigned to two separate plungers. The forcing plunger *p* is positively operated from an eccentric or crank at constant stroke while the measuring plunger *m* derives its movement from the former through a system of levers. Regulation is obtained by means of bell crank *c* which permits the governor to shift the fulcrum of lever *a*. With this arrangement the measuring is accomplished under the moderate pressure head at which the oil usually flows to the pump, and a gland at the measuring pump plunger can be dispensed with, thus reducing friction to a minimum so that practically no reaction should manifest itself at the governor. The above-mentioned disadvantages of the variable stroke plunger arrangement for heavy work have thereby been overcome, although the rather complicated mechanical structure requires careful design and workmanship in order to prevent excessive wear at its many links and pins.

Two typical forms of pumps of the second method are illustrated in Figs. 19 and 20, their characteristic feature being the plunger positively operated by an eccentric crank having a displacement considerably larger than the maximum charge of fuel oil required by the engine. Regulation is obtained by the governor acting upon the suction valve through a system of levers in such a manner that during the first part of the discharge stroke this valve remains open for a longer or shorter period; after a certain amount of oil has thus been by-passed to the suction chamber the valve returns to its seat and during the remainder of the stroke oil is forced to the engine. With the exception of slight modifications in details of construction, Figs. 19 and 20 are representative of the most generally used method of regulation on Continental Diesel engines; one and the same pump lends itself readily to a wide variety of engine sizes by simply varying the point of closing of the suction valve. But the present patent situation in the United States will undoubtedly greatly restrict the use of such pumps for some time to come.

Fig. 21 shows a pump of the third method, where the capacity of the pump chamber is varied independently of the pump plunger. The latter is again positively driven and has, therefore, a constant stroke and displacement. One end of the pump chamber is formed by a diaphragm which is secured at its outer

periphery so that it lies normally flat as shown. At the beginning of the discharge stroke the pressure exerted upon the oil in the pump chamber causes the diaphragm to deflect until it lies against the unyieldable stop *m*, and the remainder of the oil is then forced to the engine. On the next suction stroke the diaphragm returns to its flat position and a new supply of oil is taken in through the suction valve *s*, the amount of oil enclosed in the pump chamber at the beginning of each discharge stroke being, therefore, always the same. Regulation is obtained by changing the position of stop *m* by means of wedge *a*, which is connected to the governor and against which the stem of stop *m* rests. It will be noticed that this pump regulates by changing its clearance space, in which a variable quantity of oil can be stored while the remainder goes to the engine.

The longitudinal and cross-sectional views, Fig. 22, give an idea of the constructional details of a pump of this principle. It is provided with two diaphragms, one on each side, and the stops which limit the deflection of the diaphragms are made up of a series of segments, *S*, supported at their outer periphery on the covers *C*, while their inner ends engage with the regulating screws *R*. The latter are acted upon by the governor through levers L_1 and L_2, which turn these screws over a larger or smaller angle according to the change in the position of the governor collar, and segments *S* are accordingly tilted from their straight position thus permitting the diaphragms to deflect more or less. The pitch of screws *S* is determined in such a way that, for a given maximum governor collar travel, the corresponding deflection of the diaphragms will always be within a very safe limit, never amounting to more than $\frac{1}{32}$ in. In other words, their maximum deflection corresponds to a load which is only a very small fraction of the pressure against which the oil is forced to the engine. Since these diaphragms are in any position supported over their whole surface by unyieldable rigid supports, it is the latter that carry the full load, leaving the diaphragms unaffected. A part of the load thus carried by the segments, *S*, will be transmitted to the regulating screws which might be expected to produce sufficient frictional resistance to temporarily render the governor inoperative, but in actual practice it was found that this resistance is either not sufficient or else the time during which it manifests itself too short to lock completely the governor. It has, however, a beneficial dampening effect, similar to a dash-pot, which effectively prevents oscillations, for instance, during rapid changes of load, and the essential requirements for close regulation are thus met with extremely simple means.

This pump has only one plunger, and for multi-cylinder engines provisions must therefore be made to distribute the oil equally to the various cylinders. A so-called distributor, *B*, which in Fig. 22 is shown for a three-cylinder engine, is used for this purpose. Since there is usually a considerable difference in the distance and, therefore, resistance of the oil pipes between the fuel pump and the various engine cylinders, means must be provided whereby these resistances can be equalized, and this is accomplished by means of calibrated orifices *O* which may be throttled more or less with the needle valves *N*. With this arrangement sufficiently close adjustments can be made to obtain indicator cards in the various engine cylinders which do not differ more than 2 to 3 per cent from one another, and it is still an open question whether or not these slight discrepancies, which might from other sources become considerably larger, warrant the use of a separate pump for each cylinder; the greater complication and expense of this latter expedient seem hardly warranted for small and medium size engines.

There are a number of details which, although known from gas engine practice, have had to undergo

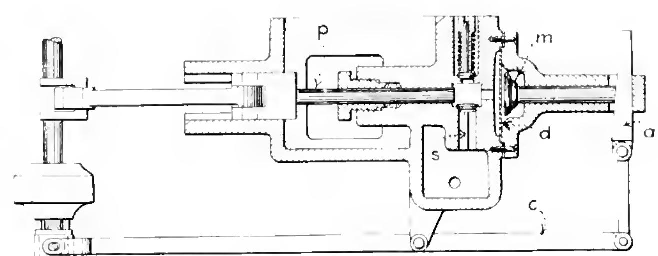


FIG. 21 METHOD OF GOVERNING BY VARIATION OF CAPACITY OF PUMP CHAMBER

a distinct development of their own in order to meet Diesel engine requirements, but instead of discussing them, I wish to point out a few general features of an American-built Diesel engine. Fig. 23 illustrates the Fulton-Tosi oil engine, which in its general appearance resembles the typical moderate-speed Diesel engine as it is built to-day by the leading European manufacturers. The main engine structure consists of an individual A-frame for each cylinder, mounted on a shallow base plate of box section. The main bearings as well as the crank and piston pin boxes are designed in accordance with the considerations laid down in the early part of this paper. This method of journaling the moving parts, together with the individual A-frames with their central load transmission and resulting freedom from uncontrollable strains, insure maximum rigidity and, therefore, maintenance of accurate fits and alignments. The upper part of these A-frames forms the cylinder jacket into which the cylinder proper is inserted in the form of a liner, held at the top by means of the cylinder head and free to expand longitudinally. Owing to the uniform cooling which insures the maintenance of a true cylindrical liner the piston can be made exceptionally long, thus reducing the unit side pressure due to the connecting

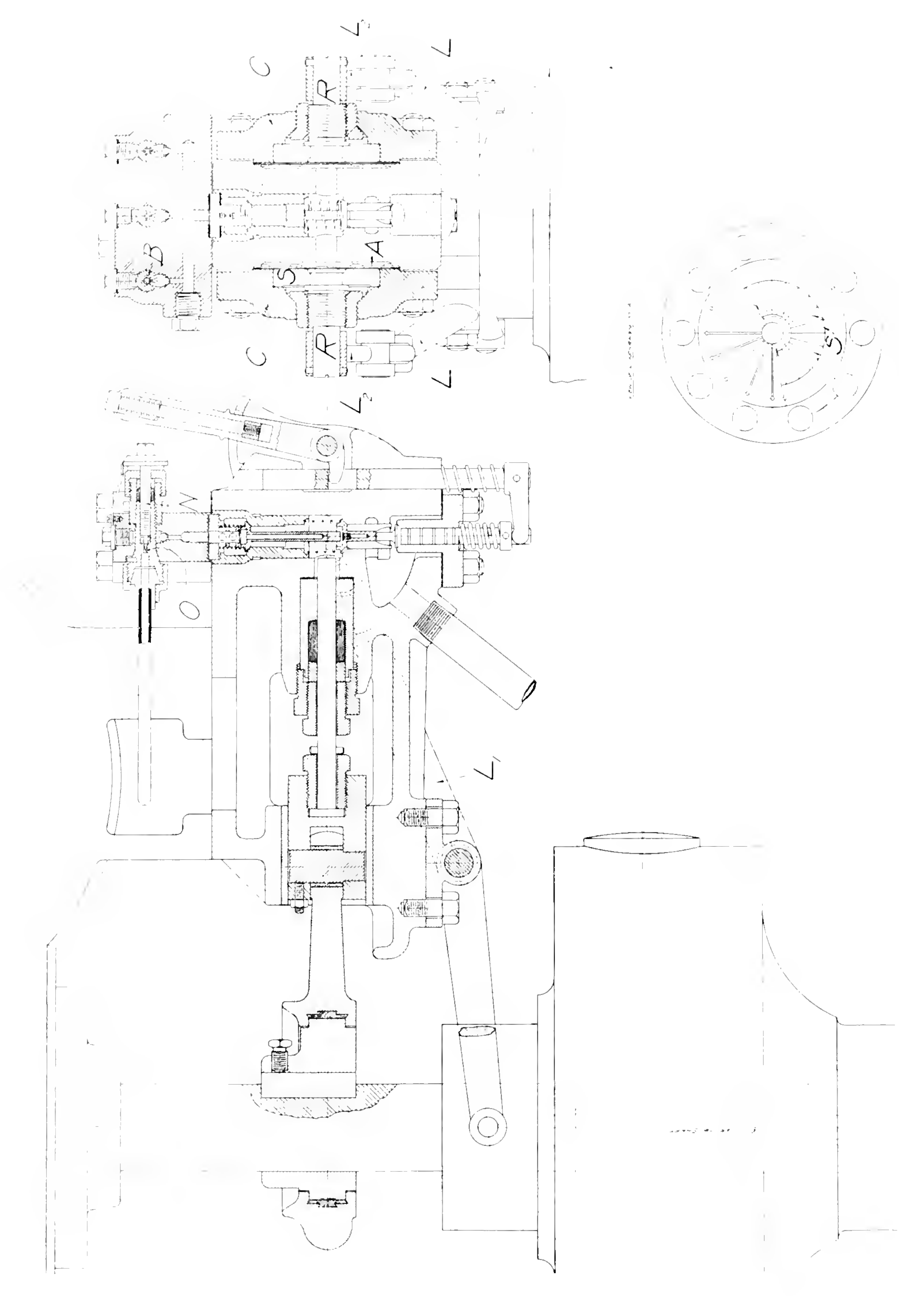


FIG. 22 CONSTRUCTIONAL DETAILS OF A FUEL INJECTION PUMP DESIGNED TO GOVERN BY VARIATION OF CAPACITY OF THE PUMP CHAMBER

rod thrust to a figure which insures minimum wear. The nicety with which this very important requirement can be met on vertical engines is another reason for their unsurpassed success; it is today not at all unusual to find such engines in which the pistons, after five and more years of hard service, are still fitting their cylinders perfectly. Fig. 23 shows one of these engines of 150 h.p. on the testing floor.

After all these foregoing considerations have been duly taken into account, it is proper to state that another most important requirement is an equipment in the machine-shop that will enable the observation of painstaking accuracy and fits which on many parts must not vary more than a few ten-thousandths of an inch. In the early history of its commercial development it occurred several times that leading concerns could not "make a go" of the Diesel engine, although they had used designs which had proven their success where first brought into existence, and as a consequence the manufacture was repeatedly dropped as unprofitable only to be taken up again later on. In the

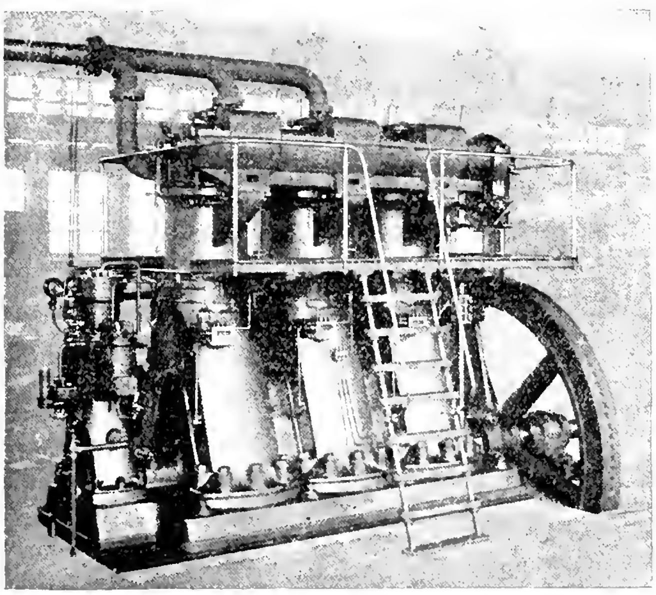


Fig. 23 View of a 150 H. P. Fulton-Tosi Diesel Oil Engine on the Testing Floor

meantime it had been proven that it was mostly lack of appreciation of the accuracy of workmanship required that had caused these early negative results. Both the tools and the measuring facilities were generally inadequate, especially the latter, the limit system of measurements being at that time very little understood; accurate work and proper fits depended in a great many shops entirely on the experience of the machinist who usually had to make all those parts that went together. Fortunately the advantages of interchangeability in the manufacture of machinery have been early recognized here and at least the leading American shops should today be able to approach the manufacture of Diesel engines with a clear understanding of the essential methods to be followed.

It is hardly necessary to emphasize the fact that a considerable amount of preparatory work, both in the form of effort and capital, is involved before the manufacture of Diesel engines can be carried out on a commercial basis, which alone will make it possible to realize any returns from the enterprise. The immediate question then is will the commercial possibilities warrant such an investment, and to answer this, we must first compare the Diesel engine with the other existing forms of prime movers. A good idea as to their relative economies may be had from Fig. 26, which is based upon representative test results on engines ranging from about 150 b.h.p. to about 600 b.h.p. capacity. Non-condensing steam engines, for instance, show a heat

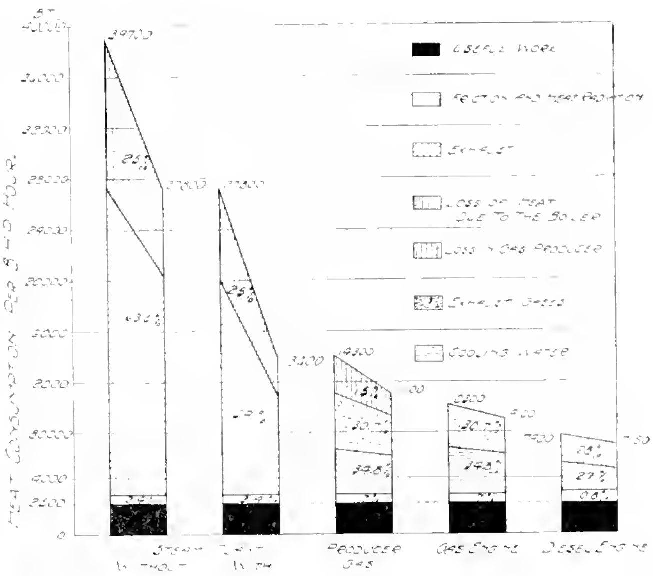


Fig. 24 Diagram showing Relative Economies of Steam Engines, Gas Engines and Diesel Engines

consumption per b.h.p. varying from 39,700 B.t.u. on the smaller sizes down to about 27,800 B.t.u. on larger units. These test results are, however, seldom if ever realized in actual practice, by far the large majority of steam plants, both condensing and non-condensing, as well as the producer plants, showing considerably higher consumptions under actual running conditions. While this applies to a lesser degree even to gas engines, this influence is entirely eliminated in the Diesel engine, and it is a matter of common knowledge today that its superior economy is maintained practically unimpaired in continued operation. If to this is added the fact that these engines require considerably less labor than either a steam or producer plant, it becomes apparent at once, that for the same operating conditions, both the first cost of the Diesel plant itself and the cost of the fuel used therein may be considerably higher than the corresponding figures for a steam and even producer plant of the same size. Just how much these differences may be depends, of course, on local conditions, such as cost of fuel, load factor, utilization of exhaust heat, etc.

This much is certain, however, that with very few exclusive cases, the Diesel engine is the coming prime mover for the whole South and Southwest. This vast section of the United States enjoys the advantage of having tremendous oil fields in such close proximity that an abundance of liquid fuels are available at a cost which compares favorably with that of coal. Based upon prices prevailing today, the cost of 1,000,000 B.t.u. bought in the form of liquid fuel ranges from 15 to 20 cents, while in the case of coal the corresponding figures will vary from 15 to 23 cents. From a monetary standpoint the two fuels are, therefore, approximately on a par, this proving that under present conditions the cost of one is regulated by that of the other.

In this connection it is interesting to note that in Germany, where during the last six years Diesel engines to an aggregate horse-power of over 500,000 have been built and installed, the cost of 1,000,000 B.t.u. bought in the form of gas or fuel oil ranges from 59 to 89 cents, as compared to from 12 to 26 cents in the form of coal. While the smaller Diesel engines can today still be operated economically under such adverse conditions, a cheaper fuel in the form of tar oil is resorted to in the case of larger installations, which makes it possible to obtain 1,000,000 B.t.u. at a cost of from 27 to 40 cents, which is still considerably higher than coal. Nevertheless, the Diesel engine, by virtue of its superior economy, easily meets the competition of the steam power plants, except in very large units, or such cases, of course, where the exhaust steam can be profitably utilized for heating purposes. This is all the more significant in view of the fact that even comparatively small German steam plants are equipped with superheaters and operated under high pressures, which materially reduces the coal consumption as compared to the average American steam plant of the same capacity.

This comparison furthermore brings out the fact that conditions for the operation of Diesel engines are far less favorable in Germany, where this type of prime mover is today holding almost uncontested sway, than in even less advantageous sections of the United States than the South and Southwest. The hundreds of oil-fired steam plants in this latter part of the country are bound to rapidly disappear. Present economical conditions imperatively demand conservation of national wealth, be that in the form of natural resources or human efforts. That the Diesel engine means a tremendous factor in this problem of economies could not be better expressed than by the fact that it enables the production of a barrel of flour at from $1\frac{1}{2}$ to $1\frac{3}{4}$ cents for fuel oil, compared to 8 and 10 cents, and even more, for steam; or the pumping of water at from 7 to 9 gal. of fuel oil per 100 water horsepower against 50 to 60 gal. for steam plants. Similar remarkable results are obtainable in the operation of ice and electric power plants.

Provided due consideration is given by the manufacturers and engineers to the particular problems involved in the construction of this prime mover, and the matter is earnestly studied along such lines as laid down in the foregoing, American engineers will soon learn to discriminate between reliable and questionable features of design and construction. Moreover, they will begin to realize that price is not the first consideration in the purchase of oil engines; the lower cost of an engine which is inferior in regard to details of construction can never compensate for the resulting shut-downs and repairs. This is a point of far more than individual importance, since the failure of one installation due to cheap and unsuitable design will seldom be traced to its source. Much more frequently the opposite occurs and the whole class of similar prime movers is condemned. It would be deplorable if many such cases should have to be recorded after the Diesel engine has made such remarkable progress in other countries, since the public at large would thereby be deprived of one of the most remarkable products of modern technical development.

CLASSIFICATION AND HEATING VALUE OF AMERICAN COALS

BY WILLIAM KENT, NEW YORK CITY

Member of the Society

THE recent publication by the United States Bureau of Mines in Bulletin No. 22 of over 3000 analyses and results of calorimetric examinations of American coals offers the best opportunity that has ever been had for a study of the long-mooted questions of the classifications of coals and of the relation of their chemical composition to their heating value.

The writer has made an attempt at such a study and gives the principal results of it herewith, although they are by no means complete. It was not possible in the limited time at his disposal to take all the analyses of heating values and compare them, but instead he has made a selection of 155 analyses of coals from different states, showing practically the extreme range of composition of heating value of the coals of each of these states, whenever a sufficient number of coals of such states are given in the bulletin. The most important items of the ultimate and proximate analyses were tabulated, viz., the S, H, C, O, and N of the ultimate analysis as referred to the combustible (coal free of moisture and ash), also the volatile matter, the moisture and the ash of the proximate analysis, the moisture and ash being referred to the coal as received, and the volatile matter being referred to the combustible.[1] The fixed carbon was omitted in order to save space. Referred to combustible it is 100 per cent minus the volatile matter of the combustible, and referred to coal as received it is 100 per cent minus the sum of moisture ash and volatile matter.

The actual analyses, both proximate and ultimate, were made on air-dried coal, the surface moisture having been first removed. The results as given in the bulletin are calculated to three different bases: (1) as received, (2) dry coal, (3) ash and moisture free (commonly called combustible); and in many cases to a fourth basis, ash, moisture and sulphur-free. For the purpose of comparison, however, other information was desired, such as the B.t.u. per lb. of coal air-dry, ash-free, and air-dry, ash and sulphur-free, not contained in the bulletin. The writer has calculated and tabulated these omitted items, but it should be stated that the figures which he obtained relating to B.t.u. calculated to the sulphur-free basis, are probably too high in many cases of high sulphur coals, as will be shown later.

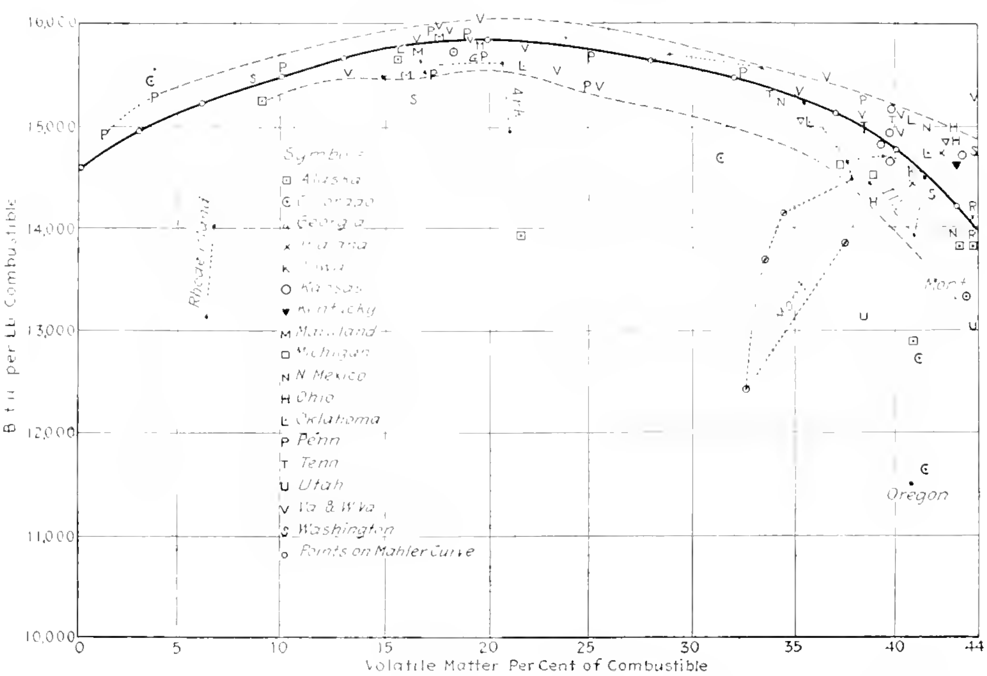


FIG. 1 RELATION OF HEATING VALUE TO PERCENTAGE OF VOLATILE MATTER IN THE COMBUSTIBLE

Having thus tabulated the results, the questions to be solved are (1) how shall the coals be classified: (2) what relation does the heating value of the coals bear to the chemical composition.

The earliest published classification of American coals is that of Persifor Frazer, Jr., in 1874 (Trans.

[1] See Table 1.

Presented at the Spring Meeting, at St. Paul-Minneapolis, 1914, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

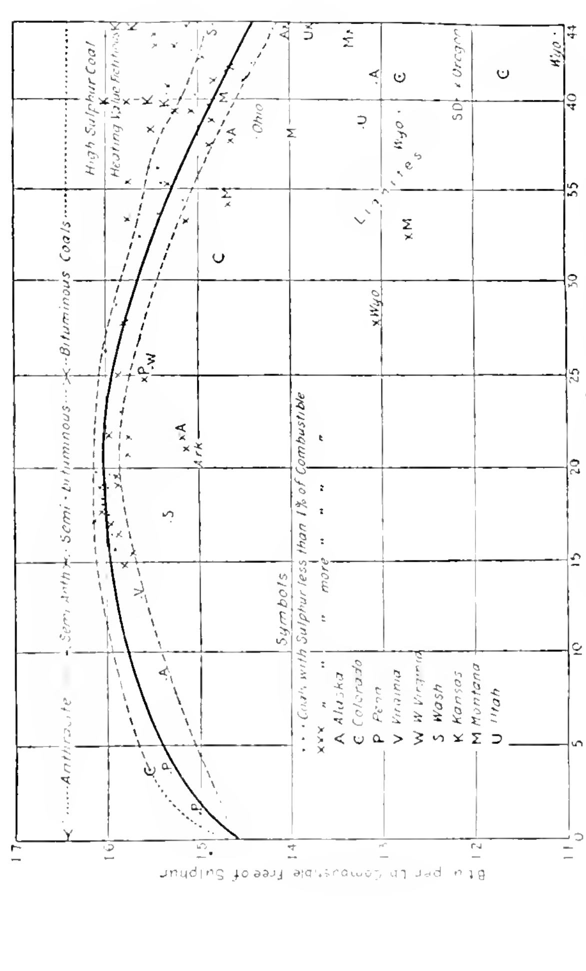


FIG. 2 RELATION OF HEATING VALUE TO VOLATILE MATTER IN COMBUSTIBLE FREE OF SULPHUR

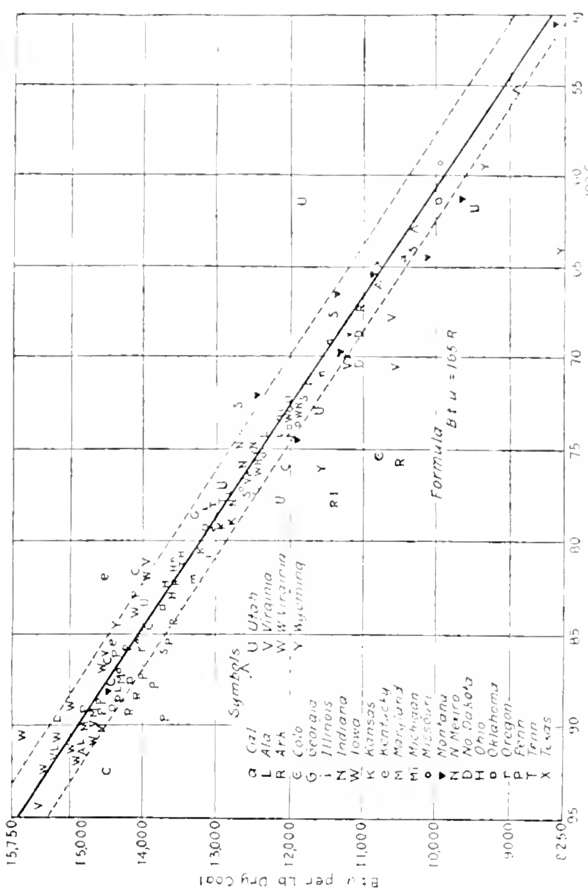


FIG. 3 RELATION OF HEATING VALUE TO CARBON REFERRED TO SUM OF CARBON, OXYGEN AND ASH

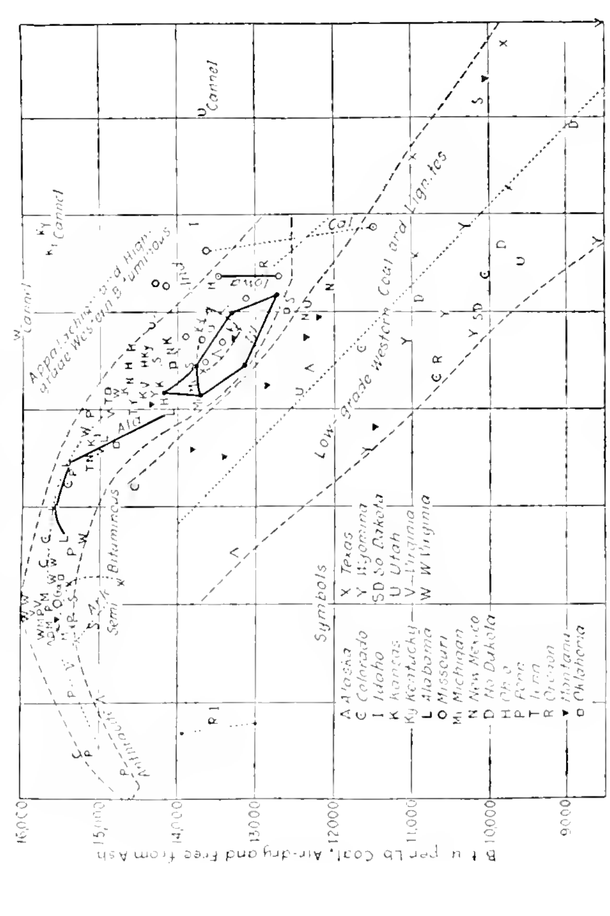


FIG. 4 RELATION OF HEATING VALUE TO FIXED CARBON IN AIR-DRY COAL, FREE FROM ASH

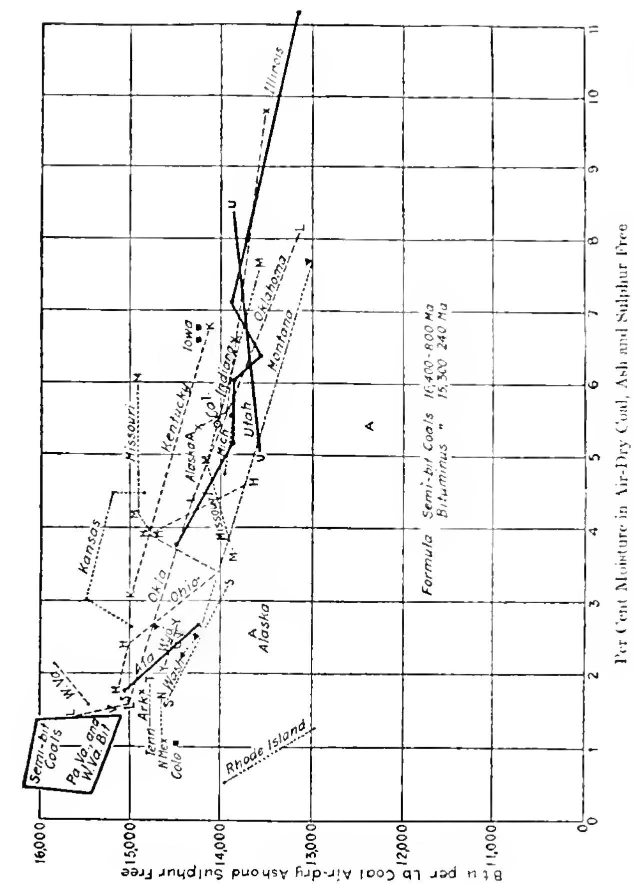


FIG. 5 RELATION OF HEATING VALUE TO MOISTURE IN AIR-DRY COAL, ASH AND SULPHUR FREE

TABLE 1 CLASSIFICATION OF COALS

		Volatile Matter Per Cent of Combustible	Oxygen in Combustible Per Cent	Moisture in Air Dry Coal Free from Ash Per Cent	B.t.u per Lb. Combustible	B.t.u. per Lb. Coal Air Dry Ash Free
I	Anthracite	less than 10	1 to 4	less than 1.8	14,800 to 15,400	14,600 to 15,400
II	Semi-anthracite	10 to 15	1 to 5	less than 1.8	15,400 to 15,500	15,200 to 15,500
III	Semi-bituminous	15 to 30	1 to 6	less than 1.8	15,400 to 16,050	15,300 to 16,000
IV	Cannel*	45 to 60	5 to 8	less than 1.8	15,700 to 16,200	15,500 to 16,050
V	Bituminous, high grade	30 to 45	5 to 14	1 to 4	14,800 to 15,600	14,350 to 15,500
VI	Bituminous, medium grade	32 to 50	6 to 14	2.5 to 6.5	13,800 to 15,100	13,400 to 14,400
VII	Bituminous, low grade	32 to 50	7 to 14	5 to 12	12,400 to 14,600	11,300 to 13,400
VIII	Sub-bituminous and lignite	27 to 60	10 to 33	7 to 26	9,600 to 13,250	7,400 to 11,650

* Eastern cannel. The Utah cannel is much lower in heating value.

A.I.M.E.). He divided the coals into anthracite, semi-anthracite, semi-bituminous and bituminous, and he used what he called the "fuel-ratio" or the ratio of fixed carbon to the volatile matter in the combustible, as the basis of subdivision between the several classes. The names he used are still retained, although the figures of fuel-ratio which he gave are no longer accepted as marking the divisions into classes, but the bituminous coals have been divided into two or more classes, as bituminous and lignite, and the lignites have been recently subdivided by the U. S. Geological Survey and the Bureau of Mines into sub-bituminous and lignite.

Frazer's method of using the ratio of one constituent to another, or of one to the sum of two others, has been followed by several writers, such as David White,[2] who uses the ratio $\frac{C}{O+A}$ in which C, O and A are respectively the carbon, oxygen and ash in the dry coal. The expression of the relation of two elements as a ratio is not as convenient for the purpose in view as the expression of the same relation as a percentage, or the ratio of one of the two elements to the sum of the two. Thus by Frazer's method two coals having fuel ratios differing as widely as $\frac{97}{3} = 32.3$ and $\frac{92}{8} = 11.5$ are both anthracites, the first having 3 per cent and the second 8 per cent of volatile matter in the combustible, while two other coals, also differing 5 per cent, viz., one with 48 and the other 53 per cent of volatile matter in the combustible, have fuel ratios that differ but little, or $\frac{52}{48} = 1.08$ and $\frac{47}{53} = 0.90$. Mr. White plots the B.t.u. per lb. dry coal as ordinates and the ratio $\frac{C}{O+A}$ as abscissae, and obtains a curve that begins in a nearly vertical direction, where with coal very high in oxygen and ash the ratio is less than 1, and ends in a direction that is nearly horizontal, becoming actually horizontal when $\frac{C}{O+A} = 0$ and the ratio becomes infinity, while if he had plotted the B.t.u. against the ratio $\frac{C}{C+O+A}$, which may be expressed as a percentage, the curve would have become an inclined straight line.

In 1892 the writer published in Mineral Industry the results of a study of Mahler's researches on European coals, in which by means of plotting the B.t.u. against the percentage of fixed carbon in the combustible and drawing a curve through the plotted points, he showed that the B.t.u. per pound of combustible of the coal tested by Mahler was related to the percentage of volatile matter in the combustible. Messrs. Lord and Haas published later the results of their tests of Pennsylvania, Virginia, and Ohio coals and stated that they had found no such relation, but on the contrary that the combustible portion of coals of certain districts had remarkably uniform heating values, which were independent of the percentage of volatile matter. In a discussion of Lord and Haas's paper[3] the writer plotted their results and compared them with the curve derived from Mahler's tests, and showed that the Pocahontas coals fell on the Mahler curve, and that the tests of Pennsylvania and Ohio coals having about 45 per cent of volatile matter fell within the Mahler field, showing a variation of 3 or 4 per cent as maximum from the curve, but that as Lord and Haas said, each coal district had a law of its own, and that two Ohio coals from different districts in the same state each with the same percentage of volatile matter in the combustible might vary 6 or 8 per cent in heating value per pound of combustible.

In studying the 155 coals, the writer first plotted the B.t.u. per lb. combustible with the results which are shown graphically in Fig. 1. This plotting shows that all the coals of the Appalachian field come close to the original curve drawn from Mahler's tests of European coals, when the volatile matter in the combustible is 35 per cent or less. For coals higher in volatile matter, and for Western coals generally, the heating value varies over a wide range and appears to have no relation to the volatile matter, but each district has a law

[2] U. S. Geol. Survey, Bulletin 382, 1909. The Effect of Oxygen in Coal. David White.

[3] Trans. A. I. M. E., Vol. 27, p. 946.

of its own. The Illinois coals are all found within the small area shown by dotted lines. Perhaps the most important conclusion from Fig. 1 is that all the semi-bituminous coals of the Eastern States, and those from the Western States and Alaska, with a very few exceptions, have a heating value per pound of combustible that is very close to 15,750 B.t.u. With bituminous coals and lignite containing over 36 per cent of volatile matter in the combustible there appears to be no law connecting the heating value with the percentage of volatile matter, and the plotting is not continued beyond 44 per cent.

As many of the coals high in volatile matter are also high in sulphur, it was attempted to find if high sulphur was the cause of some of the variation of the heating value, but the results are negative. When the heating value per pound of combustible is converted for sulphur by the usual method, by subtracting 4050

TABLE 2 CLASSIFIED LIST OF COALS

	Order in Table 1	Combustible				Air-dry Ash-free		B.t.u. Greater (+) or Less (−) than Estimated by				
								Combustible		Air-dry Ash-free		Dry Coal
		Vol.	S	O.	B.t.u.	Moist	B.t.u.	Dulong Formula	Mahler Curve	F. C. Curve	Moisture Formula	$\frac{C}{C+O-4}$
I. Anthracite												
Alaska	4	8.8	0.73	4.04	15,203	1.55	14,968	− 50	− 76	− 263	+ 87	− 172
Colo	5	3.6	0.87	1.32	15,413	1.08	15,247	− 164	+ 373	+ 305	− 183	− 756
Pa	7	1.3	1.00	2.13	14,882	1.43	14,666	+ 127	+ 172	− 243		−1102
Pa	8	3.7	0.68	2.41	15,248	0.83	15,123	− 75	+ 208	+ 193		− 693
Wash	5	8.5	0.72	2.67	15,410	0.80	15,367	− 6	+ 20	+ 93	− 385	− 453
II. Semi-Anthracite												
Ark	1	14.8	2.33	2.57	15,496	1.45	15,272	− 21	− 176	− 61		− 386
Pa	11	10.0	0.74	2.17	15,457	0.91	15,398	− 193	− 23	+ 15	− 274	− 457
Va	3	13.1	0.82	4.18	15,500	0.90	15,439	− 46	− 160	− 95	− 233	− 58
III. Semi-Bituminous												
Ala	1	28.8	0.59	4.45	15,757	1.15	15,577	− 65	+ 137	− 15	+ 165	+ 99
Ala	2	27.9	1.58	3.42	15,620	0.94	15,475	− 309	− 40	− 147	+ 23	− 176
Alaska	3	15.5	1.29	3.02	15,651	0.60	15,559	+ 13	− 109	+ 9	− 208	− 236
Ark	2	16.7	3.16	1.69	15,624	0.86	15,525	− 176	− 386	− 61	− 21	− 386
Ark	5	17.0	3.57	1.25	15,530	0.92	15,387	+ 1	− 270	− 213	+ 216	− 531
Ark	6	20.7	1.47	4.27	15,602	1.34	15,393	+ 225	− 238	− 288	+ 249	+ 23
Colo	7	23.8	0.58	4.34	15,849	0.83	15,716	+ 195	+ 49	+ 20	+ 55	+ 212
Colo	8	25.8	0.72	2.29	15,939	1.43	15,712	− 295	+ 199	+ 80	+ 443	− 22
Ga	1	19.4	1.55	5.96	15,653	0.74	15,540	+ 487	− 177	− 110	− 87	+ 345
Md	1	16.5	1.13	2.81	15,710	0.90	15,577	− 81	− 90	− 6	+ 36	− 147
Md	2	16.0	1.02	2.54	15,640	1.10	15,478	− 189	− 140	− 102	+ 72	− 284
Md	3	19.7	0.94	3.01	15,826	0.80	15,699	− 65	− 14	− 41	+ 163	− 53
Md	4	17.5	0.98	2.47	15,856	0.66	15,746	− 61	+ 30	+ 145	+ 28	− 100
Mont.	9	18.3	0.96	2.93	15,721	0.61	15,625	+ 49	− 99	+ 1	− 170	− 149
Okla	2	21.7	1.15	2.87	15,586	0.53	15,504	− 2	− 244	− 176	− 339	− 260
Okla	3	15.7	1.36	1.87	15,728	0.70	15,619	− 287	− 52	+ 63	− 56	− 287
Pa	2	19.0	1.87	3.32	15,840	0.99	15,680	+ 85	+ 10	+ 38	+ 300	+ 34
Pa	3	24.8	1.81	5.50	15,376	0.40	15,316	+ 110	− 394	− 373	− 557	− 28
Pa	4	25.0	1.50	3.72	15,660	0.86	15,523	− 203	− 110	− 160	+ 20	− 81
Pa	6	19.5	1.73	1.99	15,683	1.50	15,624	− 411	− 157	− 22	+ 643	− 308
Pa	9	17.3	1.63	2.82	15,847	0.65	15,744	+ 149	+ 47	+ 140	+ 65	− 59
Pa	10	17.2	5.09	1.66	15,493	0.76	15,378	− 95	− 307	− 226	+ 217	− 454
Va	1	19.0	0.68	3.42	15,840	0.54	15,750	+ 9	+ 10	+ 110	− 131	0
Va	5	17.5	0.68	2.23	15,910	0.64	15,795	− 236	+ 100	+ 157	− 6	− 179
Wash	6	16.3	0.48	3.97	15,264	1.67	15,013	− 209	− 516	− 588	+ 14	− 251
W. Va	2	25.3	0.86	4.13	15,399	1.18	15,218	− 370	− 371	− 458	− 314	− 306
W. Va	3	23.3	0.61	1.68	15,736	0.90	15,597	− 674	− 84	− 103	+ 55	− 348
W. Va	4	21.8	1.27	5.52	15,781	0.81	15,655	+ 516	− 49	− 29	+ 59	+ 304
W. Va	7	19.9	0.60	2.80	16,038	0.69	15,998	+ 178	+ 208	+ 270	+ 166	+ 95
W. Va.	8	16.5	0.79	4.56	15,820	0.65	15,804	+ 255	+ 40	+ 134	− 68	+ 168
W. Va	10	18.1	0.86	1.97	15,919	0.73	15,802	− 145	+ 99	+ 178	+ 100	+ 149
IV. Cannel												
Ky.	2	55.5	1.38	7.57	15,800	0.92	15,646	− 153	......	+3046	+ 198	+ 771
Ky.	3	57.0	1.15	7.61	16,013	1.14	15,784	− 91	......	+3439	+ 686	+ 967
W. Va	1	47.4	0.92	5.34	16,176	0.84	16,042	− 284	......	+2212	+ 433	+ 674
Utah	6	67.6	2.32	13.68	14,918	8.26	13,686	+ 172	......	+4974	+ 618	+1683

H in combustible, Ky. 2, 7.13; Ky. 3, 7.46; W. Va. 1, 7.13; Utah, 6, 7.73. The highest H. in the other coals is 6.78, Mo. 6.

TABLE 2 CLASSIFIED LIST OF COALS

	Order in Table 1	Combustible				Air-dry Ash-free		B.t.u. Greater (+) or Less (−) than Estimated by				
								Combustible		Air-dry Ash-free		Dry Coal
		Vol.	S	O	B.t.u.	Moist	B.t.u.	Dulong Formula	Mahler Curve	F. C. Curve	Moisture Formula	$\frac{C}{C+O+A}$
V. Bituminous, High-Grade												
Ala	3	33.4	1.13	6.99	15,590	1.23	15,400	+ 564	170	− 24	+ 120	+ 361
Ala	4	35.3	1.07	7.00	15,214	1.77	14,947	− 50	− 76	− 263	+ 87	− 172
Colo	4	31.3	0.72	9.38	14,681	1.01	14,533	+ 1	− 849	− 967	− 447	− 46
Colo	6	33.7	0.56	8.77	15,559	0.87	15,423	+ 489	− 189	− 54	− 186	+ 633
Ill	6	40.0	2.82	9.74	14,818	2.34	14,470	+ 434	+ 58	− 30	+ 268	+ 224
Kan	2	39.8	6.68	5.26	15,167	2.86	14,734	− 69	− 22	− 24	+ 908	− 54
Kan	4	39.5	4.93	7.27	14,809	2.49	14,436	− 28	− 38	− 234	+ 395	+ 6
Ky.	4	35.3	0.58	8.05	15,328	1.64	15,095	255	+ 38	− 131	− 9	+ 313
N. Mex.	1	41.5	0.74	8.79	14,875	1.64	14,630	− 145	− 375	− 40		+ 138
N. Mex.	2	34.4	0.96	6.93	15,221	0.80	15,099	− 258	− 139	− 228		+ 148
Ohio	1	45.5	4.58	8.10	14,888	1.75	14,626	+ 186		+ 586	+ 264	+ 65
Ohio	4	42.9	3.97	7.04	14,965	2.38	14,642	− 12	+ 725	+ 280	+ 330	− 46
Ohio	5	42.8	3.66	9.01	14,832	3.83	14,131	+ 480	− 572	− 83	+ 463	+ 131
Okla	5	35.5	7.36	3.71	15,025	1.38	14,814	− 299	− 185	− 412	+ 450	− 182
Okla	6	40.8	2.06	7.35	15,061	1.57	14,825	− 43	+ 461	− 151	− 73	+ 43
Pa	1	38.3	1.38	6.94	15,345	1.42	15,127	+ 132	+ 445	+ 165	+ 32	+ 165
Pa	5	32.4	1.00	7.35	15,511	1.07	15,346	+ 509	+ 31	− 98	− 76	+ 411
Tenn.	1	38.4	1.17	7.94	14,960	1.97	14,665	− 183	− 60	− 248	− 35	+ 43
Tenn.	2	33.8	0.95	6.70	15,320	1.08	15,137	− 290	− 40	− 211	− 286	+ 168
Tenn.	3	39.8	5.73	5.14	15,125	1.32	14,921	+ 11	+ 365	− 103	+ 310	− 82
Va.	1	38.3	1.32	8.01	15,156	1.79	14,887	+ 142	− 136	− 59	− 77	+ 155
Va.	2	40.2	0.85	12.48	14,918	2.52	14,381	+ 842	+ 158	− 233	+ 88	+ 619
Va.	6	35.3	0.97	5.65	15,291	1.49	15,069	− 344	+ 21	− 157	− 26	− 38
Wash.	3	44.0	5.23	13.93	14,796	1.55	14,569	+ 9		− 305	− 284	+ 778
W. Va.	5	44.3	3.86	7.06	15,291	1.58	15,048	+ 167		− 828	+ 478	+ 220
W. Va.	6	40.0	0.72	10.10	15,107	2.11	14,787	+ 555	+ 347	− 41		+ 471
W. Va.	9	36.4	0.73	5.14	15,448	1.36	15,237	+ 217	+ 238	− 94	+ 14	+ 199
Wyo	8	39.3	0.99	11.40	14,848	2.13	14,552	+ 539	− 52	− 282	− 148	+ 417
VI. Bituminous, Medium Grade												
Ala	5	37.7	1.37	10.45	14,467	2.69	14,078	+ 187	− 553	− 858	− 430	+ 26
Alaska	1	44.2	1.83	14.11	13,838	2.55	13,484	− 673		− 661	− 923	+ 217
Cal	2	53.8	4.80	11.47	14,336	5.19	13,593	− 13		+1023	+ 51	+ 127
Ill	2	41.4	1.36	12.02	14,492	5.15	13,745	+ 477	+ 392	− 589	− 179	+ 245
Ill	3	37.4	1.14	8.46	14,621	6.02	13,742	− 164	− 499	−1016	+ 8	− 241
Ill	7	39.3	3.10	9.03	14,724	3.71	14,177	+ 160	− 176	− 521	+ 105	+ 85
Ind	1	40.9	2.88	9.50	14,492	5.48	13,698	− 58	− 108	− 678	+ 19	− 39
Ind.	3	47.3	6.60	9.96	14,305	5.01	13,576	+ 169		− 76	+ 15	+ 37
Ia	2	51.2	8.53	8.96	14,206	5.35	13,445	+ 104		+ 515	+ 609	− 118
Ia	3	40.6	6.64	8.03	14,555	6.24	13,647	+ 194	− 305	− 701	+ 540	− 128
Kan.	1	44.2	9.94	5.64	14,724	4.09	14,121	− 12		− 81	+ 967	− 224
Kan.	3	39.8	5.22	5.98	14,922	4.30	14,269	− 163	− 49	− 333	+ 600	− 151
Ky.	1	44.0	4.29	8.90	14,657	6.52	13,702	+ 137		− 143	− 570	+ 37
Ky.	5	43.5	5.64	7.46	14,836	2.98	14,394	− 592	+ 736	+ 174	+ 447	− 41
Mich.	1	38.8	1.53	9.54	14,999	4.70	13,818	− 234	− 401	− 880	− 203	− 7
Mich	2	37.1	1.11	10.51	14,603	5.59	13,786	+ 118	− 517	−1017	− 52	− 156
Mo	1	44.8	5.16	9.53	14,351	4.65	13,682	− 2		− 208	+ 55	− 32
Mo.	3	44.6	4.96	11.83	13,892	3.42	13,416	+ 165		− 624	− 551	− 202
Mo.	4	50.8	6.33	7.73	14,679	3.69	14,136	− 7		+1026	+ 433	− 46
Mo.	5	45.3	9.45	6.28	14,476	2.83	13,921	− 158		+ 31	+ 618	− 229
Mo	6	50.2	6.21	6.12	15,134	5.68	14,276	− 66		+1241	+ 941	− 72
Mont.	5	34.3	4.86	9.50	14,134	2.42	13,791	− 10	−1226	+ 779	+ 414	− 207
Mont.	8	39.6	0.60	9.77	14,681	2.30	14,342	− 188	− 79	− 428	− 343	− 555
N. Mex.	3	44.3	0.68	12.70	14,539	3.06	14,093	+ 450		+ 143		+ 404
Ohio	2	37.8	0.63	11.58	14,269	4.69	14,152	− 19	− 751	− 651	− 527	− 111
Ohio	3	47.7	5.74	9.44	14,332	3.30	13,523	− 40		+ 128	− 397	− 97
Okla	4	41.7	2.31	9.26	14,711	4.31	14,075	+ 25	−1000	− 287	+ 60	+ 42
Utah.	1	45.6	0.60	13.30	14,245	4.98	13,536	+ 287		− 219	− 509	+ 201
Utah.	2	47.2	0.62	10.93	14,764	2.47	14,399	− 190		+ 674	− 244	+ 269
Wash.	[illegible]	[illegible] 8	0.57	12.38	14,348	3.26	13,879	+ 142	− 52	− 553	− 680	+ 257
Wyo	9	39.6	0.84	9.25	14,793	2.73	14,391	+ 100	+ 32	− 343	− 164	0

TABLE 2 CLASSIFIED LIST OF COALS

Order in Table 1	Combustible				Air-dry Ash-free		B.t.u. Greater (+) or Less (−) than Estimated by				
							Combustible		Air-dry Ash-free		Dry Coal
	Vol.	S	O.	B.t.u.	Moist	B.t.u.	Dulong Formula	Mahler Curve	F.C. Curve	Moisture Formula	$\frac{C}{C+O+A}$
VII. Bituminous, Low Grade											
Alaska 2	40.8	0.94	18.83	12,964	5.42	12,261	− 309	− 40	− 147	− 23	− 176
Ill 1	46.0	6.33	10.53	14,263	6.75	13,300	− 270	......	− 245	− 299	+ 79
Ill 4	40.8	5.55	12.02	13,921	6.02	13,084	− 263	− 679	−1264	− 195	− 3
Ill 5	46.2	6.02	10.09	14,155	10.59	12,657	+ 60	......	− 708	− 532	− 114
Ind 2	42.2	1.78	10.55	14,746	9.60	13,329	+ 347	+ 346	− 516	− 477	− 234
Ind 4	41.8	6.73	9.69	14,089	6.17	13,220	− 16	......	− 550	− 120	− 130
Ia 1	47.5	5.69	9.73	14,305	11.33	12,684	− 114	......	− 306	− 680	− 94
Mo 2	47.3	4.85	10.68	14,202	7.37	13,156	− 5	......	− 164	− 149	− 49
Mont 1	33.3	12.99	6.82	13,693	2.37	13,368	− 164	−1708	− 231	+ 75	− 140
Mont 2	41.4	1.72	20.44	13,338	8.75	12,170*	+1293	......	+ 820	− 866	− 565
Mont 3	43.7	2.00	15.87	13,162	6.34	12,324*	+ .13	......	+ 724	−1266	− 600
Mont 4	37.5	0.86	16.21	13,865	7.58	12,813	+ 456	−1155	+ 588	− 356	− 486
Mont 6	32.6	2.88	16.14	12,438	8.09	11,432	− 45	−3042	−1318	−1674	−2583
N. Mex 4	42.8	0.78	14.00	13,939	11.70	12,309*	+ 120	− 28	+ 997	− 107	+ 25
N. Mex 5	46.8	2.38	15.69	13,322	7.87	12,008*	+ 94	......	+1046	− 600	− 122
Okla 1	45.9	5.93	10.62	13,667	7.74	12,609	− 133	......	− 856	− 233	− 197
Ore 3	48.1	1.65	......	14,618	11.88	12,882	+ 421	−3107	+ 27	− 605	......
Utah 3	38.4	0.56	18.13	13,118	5.60	12,384	+ 723	−1782	− 109	−1522	− 89
Utah 4	45.4	7.27	10.05	13,586	9.65	12,276	− 189	......	+1114	− 35	− 676
Utah 5	44.0	7.10	14.18	13,081	11.47	11,374	− 103	......	+ 287	− 108	− 443
Wash 2	47.5	0.44	17.11	13,423	6.56	12,548	+ 255	......	+1411	−1134	− 111

* Montana 2 and 3 and New Mexico 4 and 5 are classed as sub-bituminous in Bulletin 22 of the Bureau of Mines.

Order in Table 1	Vol.	S	O.	B.t.u.	Moist	B.t.u.	Dulong Formula	Mahler Curve	F.C. Curve	Moisture Formula	$\frac{C}{C+O+A}$
VIII. Sub-Bituminous and Lignite											
Ark 3	52.1	0.96	21.17	12,497	22.00	9,750	+ 496	......	+ 75	−1190	−1960 L
Cal 1	53.5	4.62	16.79	12,890	10.95	11,478	− 107	......	− 732	− 754	−1887 S
Colo 1	41.4	0.44	16.97	11,619	8.21	10,661	−1397	−1981	−1061	−2110	−1657 S
Colo 2	45.5	0.51	16.52	13,239	15.35	10,094	+ 223	......	− 668	−1378	− 254 S
Colo 3	41.1	0.39	18.00	12,746	8.68	11,638	− 33	−1854	− 87	−1563	− 476 S
Mont 7	69.0	1.86	23.47	11,900	15.55	10,143	+ 146	......	+1774	−1365	− 221 S
Mont 10	54.1	0.67	26.64	10,211	25.02	7,656	+ 162	......	−1656	−3806	−2805 S
N. Dak 1	49.8	1.16	......	11,398	13.93	9,801	......	......	− 599	−2044	 L
N. Dak 2	56.7	2.04	17.69	12,557	26.20	8,886	+ 297	......	+ 61	+ 658	− 528 L
N. Dak 3	45.9	0.86	22.67	12,101	11.66	10,885	+ 544	......	− 202	−1517	− 241 L
Ore 1	44.0	1.15	19.68	12,769	10.16	11,471	......	......	+ 183	−1579	− 43 S
Ore 2	47.0	5.52	......	11,493	7.05	10,684	.....	......	−1203	−2473	...... S
S. Dak 1	40.0	0.68	......	12,098	15.77	10,189	......	−2662	−1123	−1267	 L
Tex 1	59.5	1.46	18.99	13,043	15.73	11,077	+ 341	.....	+1729	−1801	+ 130 L
Tex 2	70.9	1.00	....	10,811	23.58	10,169	......	......	+2002	−1003	 L
Tex 3	45.3	1.61	18.66	12,890	11.02	11,578	+ 452	......	+ 382	−1908	− 117 L
Tex 4	49.6	0.90	20.54	12,452	11.82	11,036	+ 276	......	+ 428	−2366	− 251 L
Utah 7	46.6	4.88	22.14	11,264	15.35	9,535	− 111	......	−1115	−1670	− 730 B
Wash 4	54.6	0.53	22.06	12,226	17.21	10,122	+ 307	......	+ 422	+ 14	− 183 S
Wyo 1	27.8	1.09	10.94	12,956	9.56	11,573	− 177	−2704	−1489	− 127	−1002 S
Wyo 2	44.3	0.36	24.35	11,722	9.75	10,581	+ 715	......	− 706	−1353	− 427 S
Wyo 3	39.3	0.17	21.95	12,683	12.54	11,093	+ 847	−2217	− 544	−1177	+ 30 S
Wyo 4	59.9	1.18	23.41	11,194	24.09	8,496	+ 266	......	+ 996	− 918	− 448 S
Wyo 5	47.5	4.04	17.06	12,447	18.84	10,103	+ 6	.....	− 222	− 317	− 622 S
Wyo 6	43.5	0.72	25.54	11,030	7.55	10,198	+ 521	......	−1327	−3236	− 906 B
Wyo 7	50.6	2.17	29.86	9,630	22.69	7,458	+ 492	......	−2317	−2263	−2383 S
Wyo 10	49.4	0.77	33.14	10,141	14.85	8,666	+1292	......	−1751	−3068	− 486 S
Not Classified											
R. I. 1	6.6	0.05	5.59	13,120	1.26	12,955	− 749	−2170	−2173	−2037	−1410
R. I. 2	6.3	0.09	3.27	14,002	0.52	13,930	− 207	−1208	−1138	−1237	−1536
Alaska 5	21.7	10.76	5.28	13,945	4.77	13,279	− 287	−1885	−1046	+ 297	− 313
Ark 4	21.0	1.43	6.44	14,945	1.77	14,722	......	− 895	− 13	+ 7	− 41
Idaho 1	50.9	4.77	......	16,457	16.42	13,757	......	......	+1607	+2972	......

L, Lignite; S, Sub-bituminous; B, Bituminous; Classification of the U. S. Bureau of Mines.

Wyoming 6, Sample taken 10 ft. from entrance, coal very much weathered; Wyoming 7, Surface exposure; Wyoming 10, Shallow prospect pit, coal badly weathered.

The Rhode Island coals are graphited and are not used as fuel. Alaska 5 and Arkansas 4 may be classed as semi-bituminous by their percentage of volatile matter, but they are higher in oxygen and in moisture, and lower in heating value than other semi-bituminous coals. The Idaho coal is apparently a cannel coal very high in moisture, but the ultimate analysis is lacking.

B.t.u. per lb. S, and dividing by 1 minus (C S÷100), the value thus found is often far higher than the heating value per pound of combustible of coals of the same districts that are low in sulphur. In Fig. 2 the results thus obtained are plotted, the high value referred to being shown at the upper right hand of the diagram, marked "high sulphur coals, heating values fictitious." Lower values for these coals might be found if they were converted by the "unit coal" method of Parr and Wheeler (Bulletin 37, 1909, of the Illinois University Engineering Experiment Station) viz.

$$\text{B.t.u. per pound unit coal} = \frac{\text{Indicated dry B.t.u.} - 5000\,S}{1.00 - (1.08\,\text{ash} + 0.55S)}$$

The next attempt at relating the heating value of these coals to their chemical composition was by the method of David White, modified by converting his ratio $\frac{C}{O+A}$ into percentage $\frac{C}{C+O+A}$. A straight line whose formula is B.t.u. $= 16500\,\frac{C}{C+O+A}$, may be drawn through the plotted points, but the variations of many of the points from the line indicate that the method is of little if any practical value (see Fig. 3).

Fig. 4 shows the result of plotting the B.t.u. per lb. of air-dry coal free from ash to the fixed carbon. By this method the coals are apparently divided into two principal classes: (*a*) high-grade coals including as subdivisions, anthracite, semi-anthracite, and the Appalachian and other good bituminous coals; and (*b*) low-grade Western coals and lignites. The variations from the average lines drawn through the plotted positions are in many cases so great that this method cannot be considered as of any value.

Fig. 5 shows the result of plotting the heating value per pound of air-dry coal and ash and sulphur free, against the percentage of moisture in such coal, for those cases in which the moisture does not exceed 11 per cent. The results indicate that this method may prove to be of considerable importance when it is applied separately to the coals of different states or districts, especially the bituminous coals of the Middle West. The high position of the Kansas coals and of one of the Missouri coals may be due to the error of the common method of correcting for sulphur.

After studying the coals by the method of plotting as described, Table 2 was constructed, in which a revised classification is attempted. The last five columns show the differences in B.t.u. per lb. between the B.t.u. per lb. given and those that result from calculation by Dulong's formula, by the Mahler curve, or by the average lines of Figs. 3, 4 and 5. The extent of these differences suggests that in some cases the calorimetric determinations, or the analyses, or both, may be in error and indicates the necessity for thoroughly checking the loss in air-drying, the moisture determinations of the air-dried coal, the analyses, proximate and ultimate, and the calorimetric work. The revised classification is given in Table 1.

DISCUSSION

P. F. Walker. I believe that Mr. Kent's paper throws considerable light on the coal question, but am inclined to believe that the results are of more value negatively than positively, so far as the estimation of heating values from proximate analysis is concerned.

Very shortly after coming into the Western country, nine years ago, and beginning to use the lower grades of bituminous coal in Kansas and western Missouri, I found that the heat values per pound of combustible, as published by Mr. Kent and based on his study of Mahler's researches, did not apply. Not only did the coal in general fail to match up with Eastern coal, but marked differences within a comparatively limited area occurred. This was not so surprising when one considers that some of the coal measures now being worked in Kansas are situated, stratigraphically, 2000 ft. above others.

Many of us would like to see some method established by which heat values could be estimated with a fair degree of accuracy from the proximate analysis, thus avoiding the more exact and laborious methods of the ultimate analysis and the calorimetric test alike. It is not so important to know the exact position of a given coal in a classification established on chemical properties as to know its value in heat. Is there, then, any method by which the quick and reliable estimate may be made? And more specifically, does the study of government analyses here presented to us, go far in this direction?

Emphasis is laid in this paper on air dried coal, with especial reference to its moisture content and fixed carbon content. The entire question of moisture content of coal is a complex one. In the work of analysis by the United States Bureau of Mines, air drying of samples was carried out as a laboratory convenience. The sole purpose was to bring the coal to the condition of the surrounding atmosphere to prevent change of weight during handling and weighing. In the process, air was warmed and drawn through the dryer at from 10 to 15 deg. fahr. above room temperature. The heating lowered the humidity percentage, but in all cases, the absolute degree of humidity was dependent upon the temporary conditions of the atmosphere. In the same laboratory, therefore, there might be marked differences in the extent of drying the coal at different seasons of the year as the humidity is changed far more in heating the air during the cold winter months. Also, more marked differences might occur among laboratories located in various parts of the country.

It will be observed that one set of values in Mr. Kent's table is based on moisture remaining in the coal after air drying, and the chart indicating relation of heating value to moisture in air dry coal, shows that the quantities involved are of small magnitude. Differences due to varying atmospheric conditions or varying laboratory methods, or both, are thus thrown on a relatively small quantity, and the result is apparent. The variation in fixed carbon values because of such laboratory inaccuracies as these would not be so pronounced, but the wide fluctuation of values on the Fixed Carbon basis, as shown in another chart, is due to

another were stated [illegible]. This cause is the same as that which [illegible] by the earlier Mahler method inaccurate; [illegible] the low grade bituminous coals, the volatile gases are made up of numerous hydro-carbon constituents, differing so widely in the amount of carbon which they carry from the fuel, that the solid or fixed carbon does not represent the real condition as to heat value in any such degree of regularity as is found in the case of the anthracite and other high grade coals.

A very brief analysis of results given in the final tables of the paper will show the extent of these variations. For the high grade bituminous coals, in the moisture formula column, it is seen that the variations range from −.947 to +.908. This means that in an estimation of heat value, the error ranges from 3 per cent high to 6½ per cent under. For the medium grade bituminous coals, the range is from −.923 to +.967, or from 6.4 per cent high to 7.3 per cent over. For both grades of coal, corresponding figures from the Fixed Carbon column show variations considerably greater than these even. A glance at the values in these two columns for the medium grade bituminous is sufficient to show the great magnitude of the variations between true values and these estimates.

The information presented in these tables and charts is most valuable, but I am forced to the conclusion that the way out for a simple and direct method of estimating heat values is not yet in sight. The direct calorimetric determination is a process, the labor and time for which are soon equalled by the labor and time spent in multiplying the steps in the proximate analysis and its result is to be trusted in far greater measure than that from the other can ever expect to be, especially when dealing with the lower grades of fuel. In my opinion, the most fruitful field for study in this connection is the volatile matter with its ever changing character with respect to carbon and hydrogen content.

A. G. Christie. I am inclined to agree with the opinion of Professor Walker that a proximate analysis is no reliable indication of the heating value of coal. In this connection I wish to refer to a bulletin recently published by the University of Wisconsin by Mr. O. C. Berry on the tar forming temperatures of American coals. The object of the investigation was originally in connection with gas producer work, but incidentally we found out a number of things about American coals that were embodied in that bulletin.

From investigations of the low grade coals which you get in the West, the variations in the character of the volatile matter become very prominent. It seems as though the volatile matter contained variables such as Professor Walker has stated in the carbon-hydrogen content. And also there seemed to be indications that in coals of the lignite and semi-lignite series, there were combinations of what one might call acetic and carbolic acid derivatives. Time was not available to go into an investigation of these combinations, but there did seem to be considerable quantities coming off where tar was expected. The tar from the Western coals was comparatively slight in amount and yet the volatile matter was extremely high. That would seem to indicate that there were combinations present which were not of high carbon-hydrogen ratios. The heating values of these coals were low. We found that a better indicator than any proximate analysis was shown by the ultimate analysis considering only the ratio of the carbon and hydrogen.

The Author. Referring to Mr. Christie's statement that "a proximate analysis is no reliable indication of the heating value of a coal," it would be strictly true if he added to it the words "when the volatile matter is more than 35 per cent of the combustible." When thus modified the statement would be in exact accordance with what is said in paragraph 8 of my paper, viz.: "The plotting shows that all the coals of the Appalachian field, cannel coals excepted, come close to the original curve drawn from Mahler's tests of European coals when the volatile matter in the combustible is 35 per cent or less. For coals higher in volatile matter and for Western coals generally, the heating value varies over a wide range and appears to have no relation to the volatile matter, but each district has a law of its own.

Undoubtedly, as Mr. Christie says, the character of the volatile matter in the Western coals differs widely. The chief difference is in the percentage of oxygen. For example, in seven Illinois coals the oxygen ranges from 22.3 to 29.0 per cent of the volatile matter; in six Ohio coals it is from 16.6 to 30.6 per cent; in four Oklahoma coals it is from 10.5 to 22.2 per cent, and in five Montana coals it is from 20.5 to 46.0 per cent. The percentage of oxygen might be taken as an indication of the heating value of these coals, but it is only a rough indication, for it appears that in some coals high in oxygen, part of the oxygen may be combined with carbon, instead of all being combined with hydrogen as it is assumed to be in Dulong's formula. The carbon-hydrogen ratio, for the same reason, can never be anything more than a rough indication of the heating value, for the variation in this ratio is a consequence of the variation in oxygen. If oxygen is high the carbon-hydrogen ratio must necessarily be low, as the hydrogen in all the high oxygen coals varies but little. In future studies of coal it is desirable that the carbon-hydrogen ratio be expressed as a percentage of C or H divided by $C + H$, for the reason given in the paper.

Professor Walker's statement that the results are of more value negatively than positively, as far as the estimation of heating value from proximate analysis is concerned, is correct for most of the coals mined West of the Mississippi River, and for all coals containing more than 35 per cent of volatile matter in the combustible; but there certainly is a relation between the proportion of volatile matter and the heating value in all the Eastern coals and also those of Oklahoma and Arkansas, when the volatile matter in the combustible is less than 35 per cent. It also appears that in the coals mined East of the Mississippi, as shown in the paper, there is a relation between the heating value and the moisture in the air-dried coal free from ash. In future studies of coals of particular districts, such as those of Indiana and Illinois, this relation should be investigated. This relation appears notwithstanding the probable variations in the recorded moisture, due to the variation in humidity of the atmosphere in which the coals were dried, but in future researches it should not be difficult to obtain an atmosphere of standard humidity for drying purposes, by means of a chamber in which the moisture is controlled by a hygrostat at the same time that the temperature is controlled by a thermostat.

MEETINGS

NEW YORK, OCTOBER 21

The opening meeting of the Fall in New York was held October 21, at which an interesting and timely paper was read by F. A. Waldron on Panic Economics and Emergency Problems with Special Reference to the Present Industrial Situation. The paper was well received and elicited some interesting discussion. It is published in full, with the discussion, in this issue of The Journal.

ST. PAUL, OCTOBER 22

At a meeting of the Minnesota Section held in St. Paul, October 22, 1914, Adolph F. Meyer presented his paper, Power Developments on the Mississippi River between St. Paul and Minneapolis. A large number of lantern slides, showing the construction in detail from the commencement to the present stage of the work, were used by the author. The paper was discussed by those present.

BUFFALO, OCTOBER 22

A meeting of the engineering profession of Buffalo on October 22 was addressed by Charles Whiting Baker on the topic, Engineers and Public Service. Mr. Baker spoke of the effect of the war on the world, showing a unity undreamed of in the time of Napoleon. This physical unity, he said, has been brought about by the engineer with his steamships, railroads and cables. He emphasized further the necessity for building and operating public utilities in a modern city by competent engineers and predicted radical changes during the next few years. Public sentiment is leaning more and more towards municipal ownership and operation of city utilities, and the question of their application arises. This, he said, depends entirely upon local conditions. The engineering profession must do its part by supporting the men who are chosen to fill high positions, and the engineering societies, national and local, must do all in their power to help raise the standards of public service.

LOS ANGELES, OCTOBER 28

An organization of the Los Angeles Section was held on October 28 and the by-laws were briefly discussed. A very interesting paper on Local Transportation was read by George A. Damon, dean of Throop College of Technology, outlining the desirable developments and pointing out the difficulties to be met with. The cost factors entering into the problem and the influence transportation plays in the development of our cities were dealt with, also the four main methods of transportation, surface, elevated, open cut and subway. The paper was illustrated by lantern slides, and was discussed by C. K. Mohler, transportation engineer for the city of Los Angeles, F. C. Finkle, and others.

NEW YORK, NOVEMBER 10

At the monthly meeting of the Society in New York for November, Arthur H. Lymn of London, England, delivered an address on The Development of the By-Product Gas Producer Industry in Europe. He referred to the various stages of the remarkable progress that has been made in this field, and discussed the economic possibilities from the recovery of by-products, and referred in particular to results attained with the Lymn process, of which he is the inventor. The lecture was illustrated with lantern slides and drew out some discussion.

NECROLOGY

CHARLES F. BAKER

Charles F. Baker was born at Shoreham, Vt., January 22, 1855, and in his boyhood moved with his parents to Wisconsin. He received his technical training at the University of Illinois, and his first work was with the E. P. Allis Company of Milwaukee. During his service with the company Mr. Baker had charge of some of their largest work, including the pumping engines for Allegheny City and the blowing engines for the Edgar Thompson Steel Works at Braddock, Pa. He left the Allis Company to take charge of the installation and operation of the steam plant of the C. A. Pillsbury & Company flour mill at Minneapolis.

In 1893 Mr. Baker entered the employ of the West End Street Railway Company of Boston, now the Boston Elevated Company, and ultimately became superintendent of motive power and machinery in charge of all power plants and car shops. This work included the maintenance, inspection and design of rolling stock, shops and power stations and under his supervision the East Boston, Charlestown, Dorchester and Harvard Square power stations were built. In 1905 Mr. Baker entered the employ of the Brooklyn Rapid Transit Company as superintendent of power and machinery, and while there had charge of the reconstruction of the Kent Avenue station. He then went to Baltimore as superintendent of power and construction of the local street railway, and later became associated with the Hudson and Manhattan Company as superintendent of equipment of the power station and substations.

Later Mr. Baker joined the forces of the Bay State Street Railway in Massachusetts in charge of new construction and power plant reconstruction. During this period and until the time of his death on May 21, 1914, Mr. Baker, who had meantime removed to New York to promote a very effective cooling system for generators, was engaged in private consulting engineering practice with special reference to power station economies.

Mr. Baker was a member of the New England Street Railway Club. In 1904 he was elected president of the American Railway Mechanical and Electrical Association and was also the past president of the New England Steam Railroad Club of Boston.

CHARLES W. RICHARDS

Charles W. Richards was born December 4, 1867, in New York City and received his education in the public schools. He served his apprenticeship with Joseph Edwards & Company of New York. In 1887 he entered the employ of Henry R. Worthington & Company, as machinist, and was subsequently connected with the Boston Heating Company as assistant engineer, with the United Electric Traction Company as construction engineer, with the Cunner-Richards Company, in Boston, electric construction business, with the Consolidated Electric Car Lighting Company as general manager, with Stone & Webster, in electric railroad construction, with the sales department of Chase-Shawmut Company and that of the Simplex Electric Heating Company, with the Boylston Manufacturing Company, as superintendent, and with the Stevens-Duryea Company, of Chicopee Falls, Mass., as superintendent. At the time of his death he was manager of the Driggs-Seabury Ordnance Corporation of Sharon, Pa.

Mr. Richards was a member of the Society of Automobile Engineers, and had served on the board of directors of the Connecticut Valley Metal Trades Associations.

HENRY K. ROWELL

Henry K. Rowell was born June 1, 1870, at Charlestown, Mass., and after completing his education in the public schools, entered the office of E. A. Buss, mill engineer, in Boston. He was subsequently connected with Lockwood, Greene & Company, and during the last eight years with Charles T. Main. Mr. Rowell's experience in mill work was very extensive and he was responsible for the organization and construction of many well known plants, including the textile plant of the Edwards Manufacturing Company, Augusta, Me., the textile plant of the Pepperell Manufacturing Company, Biddeford, Me., the woolen weave mill of S. Slater & Sons, Inc., Webster, Mass., and many others.

Mr. Rowell made studies, reports and valuations on many mills and wrote a number of monographs, one of which, Organization of the Carding Department in Cotton Mills, read before the National Association of Cotton Manufacturers in 1911, deserves special mention.

He died at his home in Waltham, Mass., on August 9, 1914.

JOHN CHRISTIAN HENRY STUT

John Christian Henry Stut was born in Germany on January 11, 1851, and was educated in public and private schools. He served his apprenticeship in Germany and in 1870 came to the United States, entering the Union Iron Works in San Francisco as a draftsman. He also served an apprenticeship with several firms in the same city. He designed the plans for the American Sugar Refinery in that city in 1885, and acted as constructing engineer for the Cable Railroad, during his association with the Omnibus Cable Company. He was also associated with the Presidio & Ferries Railroad of San Francisco and the California Street Cable Railroad as constructing engineer, and designed the plans for the Alameda Sugar Company at Alvarado, Cal.

At the time of his death Mr. Stut had for a number of years conducted a private consulting business, specializing in cable and electric roads, sugar refineries, etc.

WARREN H. TAYLOR

Warren H. Taylor, one of the best bank lock and fine lock experts in the country, and superintendent of the bank lock department of Yale & Towne Manufacturing Company, died at his home in Stamford, Conn., on June 11, 1914. Mr. Taylor was born in Winchendon, Mass., February 17, 1846, and was educated in public and private schools. He served an apprenticeship as a machinist with his uncle in Milford, N. H.

When the Civil War broke out Mr. Taylor, though quite young, enlisted in a New Hampshire regiment, but was prevented by illness from going into service. Upon his recovery he returned to his trade of machinist, entering the employ of a sewing machine company at Winchendon, where he remained a year and a half. Subsequently he worked for the Smith & Wesson Arms Company, Springfield, Mass., the Remington Arms Company, Ilion, N. Y., for a lock company founded by Linus Yale's father at Newport, N. Y., and for Linus Yale, Jr., at Shelburne Falls, Mass., with the company which has since become the Yale & Towne Manufacturing Company of Stamford. In the spring of 1868 Mr. Taylor went with Mr. Yale to Stamford and was with the firm until the time of his death. The many inventions and patents which have been issued to him in conjunction with the manufacture of their products, numbering over 200, are universally known.

During his many years of service with the company he was associated with about every branch its operations cover. It is an interesting fact that at the beginning of his service he was associated with the bank-lock department and at the end he was the head of the department. During about ten years he acted as general superintendent of the company. Most of Mr. Taylor's inventions had to do with pin locks, but he made a number of important inventions in connection with post office lock boxes which have been used by the United States Government.

Mr. Taylor took an active interest in public affairs and was a member of the Board of Appropriation and Apportionment. He was one of the charter members of the Board of Trade. He was a member of the Stamford Yacht Club, the Democratic Club of New York, and the Reform Club of New York.

WILLIAM DEHERTBURN WASHINGTON

William DeHertburn Washington was born June 29, 1863, and died August 30, 1914, in Hanover County, Virginia. He received his early education at private schools and at the Maryland Agricultural College, where he took a special course in mathematics with a view to entering the United States Naval Academy. He changed his plans, however, and at the age of sixteen began work on an engineering corps of the Canal and Iron Railway. He was afterwards assistant resident engineer on the construction of the West Virginia Central & Pittsburgh Railway, and later in the office of the Atlantic & Pacific Ship Canal Company. He entered the employ of C. W. Hathaway & Company as a designer of special machinery, and designed many original mechanical devices, including steam engines, air separators, methods of hydraulic sheet piling, and a system of sinking caissons hydraulically, which has been successfully used in many of the large buildings in New York City.

At the time of his death Mr. Washington was president of the Hydraulic Construction Company, New York, which has engineered and constructed many important industrial plants in the United States. He was appointed by Governor Sulzer as consulting engineer to the Highway Commission of the State of New York, and was a delegate to the Third International Road Congress. He was a member of the American Society of Civil Engineers, the American Institute of Mining Engineers, and a fellow of the National Geographical Society.

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

While in general, foreign engineering periodicals are published, at least in sections of Europe not directly affected by the war without much interruption, the events begin to affect their size and wealth of material, some of the papers having cut down the numbers of the issues, and others the number of pages. As is mentioned in one of the articles abstracted in this issue, some projected investigations have been stopped for lack of funds owing to the general tendency to economize on everything that does not bear directly on the war. Another regrettable feature of the present situation is the long lists of "dead for their country" published by some of the European engineering societies and representing a grievous waste of the best constructive forces of their respective countries.

THIS MONTH'S ARTICLES.

The first article treats of the proper dimensioning of heating surfaces in heating installations where steam, either exhaust or live is used, and among other things, describes the arrangement used when the waste heat of internal combustion engines is utilized. The article is not yet finished. It may be explained here, by the way, that contrary to the usual practice of the Engineering Survey, several unfinished articles have been abstracted in this issue. This is done because foreign papers now come irregularly, several issues at one time, and that there may be a long delay when none are received. Under these conditions to wait until the entire text of the original article is at hand would be contrary to the policy of the Survey to be as much up to date in its information as possible, and so the plan is to give abstracts of such unfinished articles as present in the part available, sufficient data to make them of immediate interest.

In the section Internal Combustion Engineering is given a description of two new types of gas producers, one of which is especially adapted to handle vegetable refuse and particularly seaweed, in the latter case with the recovery of potash and potassium carbonate.

In the section Steam Engineering are described straight-flow rolling mill engines, and interesting data are given on the jet condenser connected with it. The data of tests with recording load meters on steam engines are of particular interest in these days of vigorous effort to secure maximum efficiency of apparatus used. Besides, as shown in the article, the use of the recording indicator enables one sometimes to locate trouble of an otherwise elusive character. In Schulz's article on temperature measurements in evaporation tests is discussed the still mooted question (in Germany) as to what is the entrance to the economizer, and how thermometers in evaporation tests should be placed. Valuable data on the distribution of temperature in the economizer are cited. Pradel's description of the Pellegrino grate forms part of his usual quarterly account of progress made in the field of boiler firing, the closing part of which will be abstracted in an early issue of *The Journal*.

In the section Thermodynamics are reported two important investigations, Hornborn and Jakob's on the specific heat of air at 60 deg. cent. and various pressures, up to 200 atmospheres; and of Stodola on the phenomenon of undercooling of steam flowing out from nozzles.

In the paper presented by F. G. Cutler before the American Iron and Steel Institute are described some of the improvements in power generation made at the Ensley plant of the Tennessee Coal, Iron and Railroad Company. Their great importance and extent can be judged from the author's statement that "the saving in coal with the present equipment and methods of operating over the former practice is estimated to be at the rate of 200,000 tons per annum." R. L. Daugherty, in a paper before the American Society of Civil Engineers, presents data on the performance of a reaction turbine made at Cornell University with a greater thoroughness than is usually the case with commercial tests.

Two papers are reported from the Journal of the American Society of Marine Draftsmen, a new publication which we take this opportunity to welcome.

Temperature Cycles in Heat Engines, by Professor F. G. Coker and W. A. Scoble, and Seventh Report of the Explosion Committee, are the titles of two papers before the Australian meeting of the British Association which have already attracted considerable attention in the European scientific and technical press. The second of these papers describes, among other things, methods of measuring the temperature in the cylinder of an explosion engine so as to determine it at various parts of the cycle.

The locomotive arch brick is the topic discussed by G. Wagstaff before the Central Railway Club. It contains statistical data concerning engines equipped with fire brick arches in this country and Canada.

A method of determining the internal stresses in heat treated axles, and a discussion of the influence of quenching by horizontal or vertical immersion form the subject of a highly interesting investigation, by H. V. Wille, published in the Journal of the Franklin Institute.

From the recent publication of the Institution of Mechanical Engineers are abstracted the report of the Refrigeration Research Committee, and the paper of Dr. W. E. Fisher on the Discharge of Steam through Nozzles. A paper on the Theory of Flow of Gases through Nozzles, by J. G. Stewart, had to be left out for an early issue on account of lack of space.

Finally, from the Quarterly of the School of Mines has been taken an account of the recent tests on the physical properties of steel and cast iron bars broken at various temperatures.

Heating

UTILIZATION OF EXHAUST HEAT OF ENGINES FOR PURPOSES OF HEATING WITH PARTICULAR REGARD TO THE DIMENSIONS OF HEATING SURFACES (*Über die Verwendung der Masheinenabwärme für Heizzwecke unter besonderer Berücksichtigung der Heizflächenbemessung*, Dr. Wilhelm Deinlein. *Zeits. des Bayerischen Revisions-Vereins*, vol. 18, no. 17, pp. 163, September 15, 1914, serial article, not finished. *dp*). There is quite a large amount of information in existence on the utilization of waste heat of prime movers for

the purpose of room heating and water heating, but in most of the articles which have appeared so far, insufficient information is given with respect to the auxiliary apparatus used in such installations and especially with respect to dimensions of the parts. The present article takes up these features with special regard to room heating, hot water production and feed water preheating. It gives a general account of the systems of heating by exhaust steam, both exhaust in the true sense of the word and live steam used for heating purposes before its admission to the prime mover which the author calls in this case "incoming" steam. The author gives several diagrams of connections for heating by low pressure steam from an engine exhausting into the atmosphere, vacuum heating with the condensing steam engine, hot water heating from an internal combustion engine, the latter shown in Fig. 1. From condensing steam engines, water is obtained with temperatures of from 40 to 80 deg. cent. (104 to 176 deg. fahr.), according to the degree of vacuum available. With internal combustion engines (ac-

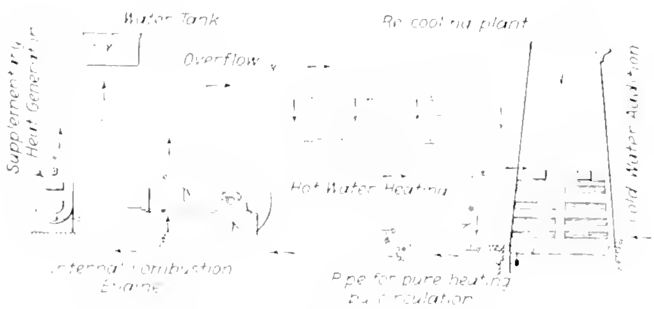


Fig. 1 Heating Installation Using Waste Heat from Internal Combustion Engine

cording to their size) water temperatures up to 70 deg. cent. can be obtained, but in the case of larger engines, especially gas engines, the temperature has to be maintained considerably below 70 deg. cent. (158 deg. fahr.). The author knows of no case where water of condensation or cooling water is used for heating purposes with supplementary heating. The possibility of such an arrangement is recognized in industrial concerns only for the purpose of heating shops and offices and the general objection to it is the low temperature of heating and the necessity of reserve installations, which involve a large investment.

Internal-Combustion Engineering

Modern Progress in the Theory and Practice of Gas Producers (*Die neuern Fortschritte in Theorie und Praxis der Generatorgaserzeugung*, J. Gwosdz. *Glückauf*, vol. 50, no. 41, October 10, 1914, serial article, not finished. *d*). The article describes the progress made during the last few years in the design of gas producers. Among the types described, of particular interest, are those of Ragot and Pierre Hervotte (French, though patented in Germany) and the German Pintsch generator, of which a new type is shown in the article. The former of the two is designed mainly to burn vegetable refuse and other cheap fuels. It has two zones of combustion, *a* and *b* (Figs. 2 A and B), located one above the other and composed of superimposed truncated cones. The downward shaft is closed by a wire screen pipe *c* and grate *d*, which is designed partly as a valve. The admission of air and steam to the upper and lower admission pipes, staggered with regard to one another, is effected through the circular pipe *e* and admission branch pipe *f*. The peculiar feature of the design is the use of the undershaft section *g* as a water container, into which the wire screen cylinder *c* and grate *d* are dropped; the gas is forced therefore to pass through the water of the container *g* before it can reach the chamber *h* and from it the gas eduction pipes. In this way, before entering into the piping, the gas is freed from impurities and such undesirable constituents as wood vinegar. The bubbling of the gas through the water container *g* helps also to break up the ashes on the grate *d* and to prevent the clogging of the interspaces between the grate bars. When plants are used as a fuel, this action of the water on the ashes helps also to recover such

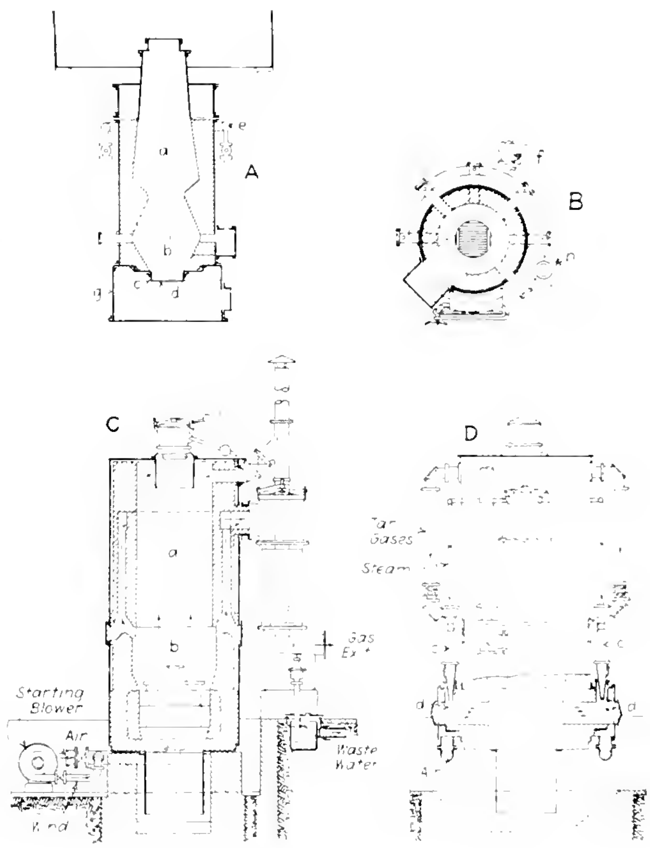


Fig. 2 New Types of Gas Producers

solids as potash and sodium carbonate. This type of producer is therefore particularly adapted for burning seaweeds along the coast region.

The development of the new Pintsch producer was based on the idea that a more effective tar separation would be obtained if the gas were freed from soot. In the producer shown in Figs. C and D, the fuel is completely distilled in the gasification shaft *a*, and taken out as coke from the gasification shaft *c*. The producer gas forms in the latter shaft for the most part closely around the gasification shaft through passages made in the brick setting and reaches the point of consumption, while a smaller part of it is taken in through suction by means of the steam jet blower *c*, through the gasification chamber and, together with the gases of distillation, reaches the hearth *d*, where the gases are mixed with the air taken in by the motor or suction

blower and are completely burned in a free flame. The products of combustion are then again for the most part converted into combustible gases in the hot zone of combustion. As shown in the figure, the contents of the shaft repose over a tank filled with water, which permits the ashes to be removed conveniently without producing any disturbance in operation. The lower heating value of the gases produced is approximately 950 to 1000 WE (1800 B.t.u. per pound), or approximately equal to the heating value of blast furnace gas, but considerably below that of the ordinary producer gas. The average composition in a 150 h.p. plant has been found to be CO_2, 8.6 per cent, CO, 18.3 per cent, H, 14 per cent and CH_4, 0.6 per cent. Thermal efficiency is from 60 to 70 per cent and the fuel combustion 0.48 to 0.59 kg. per effective h.p.

Steam Engineering

Concerning Measurement of Temperature in Evaporation Tests (*Über Temperaturmessungen bei Verdampfungsversuchen*, M. R. Schulz. *Zeits. für das gesamte Turbinenwesen*, vol. 11, no. 28, p. 419, October 10, 1914. 3 pp., 1 fig. *ep*).

The article discusses the method of taking temperature readings in evaporation tests. The author finds that in a number of tests on boilers, superheaters and economizers, the data obtained did not quite agree with the actual conditions. The author believes that the fault lies in the fact that the instruments for measuring the temperatures are not placed in the proper positions and proper parts of the gas currents. He found that in recent tests on economizers the economizer appeared, according to the test data, to have taken up more heat than was available for its use, which, of course, would be due only to improper measurements.

In Germany, guarantees of economizer performances usually state that the guaranteed performance is to be based upon the temperature at the entrance to the economizer and the author has noticed that this essential condition is not always satisfied. According to the belief of the author, the entrance to the economizer can be understood only as the place where the gases enter the economizer, and an economizer is understood as a system of piping built into a brick structure and provided with an entrance chamber and exhaust chamber. If one mixes the flue gas and air in the entrance chamber of the economizer and calls it the entrance to the economizer, only false results, according to the statement of the author, can be obtained.

To prove this, the author placed absolutely similar thermometers at the same depths of immersion. The first three of them he placed in the main flue at the entrance of the gases into the economizers at the places indicated in Fig. 3 as *a*, *b* and *c*, and then three more in the entrance chamber at the places marked *d*, *e* and *f*. The first three thermometers were placed in their three measuring holes vertically and the other three thermometers horizontally, somewhat inclined, while a seventh thermometer was placed into a hole in the cover of the economizer casing *g* vertically. At the same time, in the flue passages of the four boilers then in operation, measurements of the flue gases were made, at a distance of about 1 m. from the boiler, so that the instrument should not be affected by the heat radiated by the boiler setting.

The author asserts that it is wrong to believe that the flue gases can be materially cooled down in the main flue during the passage of from 30 to 50 m. (98 to 164 ft.) long. In the present case, the cooling amounted at most to 10 deg., although the flue was over 30 m. long. If cooling is actually established in the main flue, it is due to the fact that the valves are so lacking in tightness that large amounts of air are permitted to enter, or possibly the valves are open on other boilers which are connected with the smokestack but are not in operation (perhaps because they were being cleaned). It is of great importance, therefore, during the test, to allow no cold air to enter into the main flue, and it is best to have the valves on the boilers which are not in operation covered with clay.

The measurements in the main flue at the entrance to the economizers were carried out by three pyrometers of equal length in such a way that all the pyrometers were placed at equal depths into the setting at a distance of about 400 mm. (15.7 in.) from one another. The thermometers were changed in position several times and the results were always

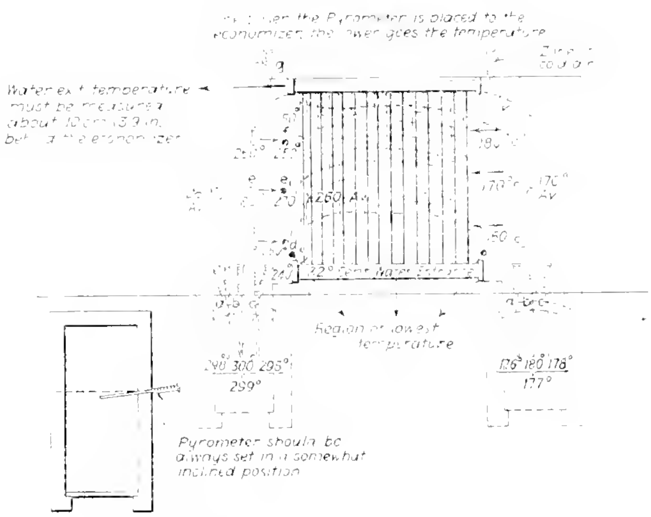


Fig. 3 Temperature Measurements in Evaporation Tests

the same. The two outer thermometers always indicated a little less than the middle one, which leads to the conclusion that both outer thermometers had been somewhat effected by the temperature of the brick work of the side walls. Quite noticeable, however, was the difference in temperature at the three places, *a*, *b*, *c* and *d*, *e*, *f*. The thermometer at *d* indicated always the same temperature, if it was placed low enough. The other two thermometers indicated lower temperatures, so that even in an economizer 3 m. wide one could observe a difference in temperature between instruments placed at *a*, *b*, *c* and those placed at *d*, *e*, *f*—a difference of 30 deg. cent. (54 deg. fahr.) over an average distance of $1\frac{1}{2}$ m. only; the vertical thermometer still less, only about 250 deg. The author noticed, however, that the vertical thermometer at *g* was not placed quite vertically over the three other holes and was inclined somewhat in the direction of the economizer.

Even though this fact appeared sufficient to prove that it is not correct to effect measurements in the front chamber, the author carried out further measurements in the rear chamber of the economizer. Here the difference in temperatures was not as great as it was at the entrance, which ap-

peared to be due to the fact that a very considerable amount of cold air was allowed to enter through numerous leaks and that this materially increased the volume of the gases. Further temperature measurements were then undertaken, the three thermometers being taken out from *d, e, f* and placed at the same height into the economizer brick setting, where it was found that at the points *d, e, f* entirely different results were obtained; to wit, 260, 270 and 250 deg. cent., respectively (500, 518 and 482 deg. fahr.). These measurements were effected at a distance of approximately 300 mm. (11.8 in.) from the collector piping, and gave an average figure of 260 deg. cent. Here again 10 deg. have been lost in the distance from the lowest point of measurement of 20 deg. from the entrance to the economizer. Finally, the thermometer was shifted from *d* to *f*, or quite close to the first row of pipes on the lower collector piping, which gave a flue gas temperature of 240 deg. The same operations were carried on with the upper thermometer, but there a difference at most from 5 to 10 deg. could be found.

Further tests were made in the economizer casing at various places, but always along the same vertical line, and it was found that in the lower third part of the economizer the flue gas temperatures were quite low. This difference in measurements is explained by the author on the basis of an assumption that in order to determine the temperature under similar conditions, not only an accurately indicating pyrometer is necessary, but it is also necessary that the measurements should always be effected under practically equal conditions. By this equality of conditions, the author understands that the depth of immersion would be absolutely equal throughout and that the velocity of flow of the flue gases at the spot where the measurements are made would be also equal. He believes that if he were to place three pyrometers in the main flue in such a manner that they would be placed radially and come with their immersion terminals exactly into the middle of the smokestack, there would probably be no difference whatever in their temperature indications. The fact that the difference in temperature between the main flue and the front chamber of the economizer is so great, he believes to be due to the fact that the measurements were not made at the same velocity of flow of flue gases. The author believes, therefore, that all measurements of temperature "at entrance to the economizer" should be made at the spot where the gases pass through the main flue into the economizer casing.

Straight Flow Steam Engine for Rolling Mill Drive, of 700 to 1000 h.p. (*Gleichstrom-Walzenzugmaschine von 700 bis 1000 PS*, E. Zix. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 40, p. 1429, October 3, 1914, 2 pp., 8 figs. *d*). The straight flow steam engine, on account of its simplicity of construction, low steam consumption and, above all, its easy adaptation to fluctuation of load, has found a wide field of application for driving rolling mills where it is displacing the tandem engine more and more. The present article describes an engine delivered to a rolling mill plant some time ago by a German concern. This engine deserves particular attention on account of certain particulars of construction and a special test made on a jet condenser connected with it. It has (Fig. 1 A to C) 750 mm. (29.4 in.) bore and 900 mm. (35.4 in.) stroke. Its speed, which varies from 110 to 140 r.p.m., can be easily adjusted to the requirements of the rolling mill during the operation, by adding supplementary springs to the governor spring. At a steam pressure of 10 atmospheres and 130 r.p.m., the normal output is 700 and the maximum output 1000 indicated h.p.h. At a steam temperature of 300 deg. cent. (572 deg. fahr.) and at least 90 per cent vacuum in the connecting pipe a consumption of 4.5 kg. (9.9 lb.) of steam per indicated h.p. is guaranteed. The cross head (Fig. D and E) is of interest on account of its easy demountability and at the same time fully reliable connection with the piston rod. The Stumpf valve gear which was used on the first engines has been discarded on account of the lack of accessibility of the axle governor and of its limiting the highest cut-off.

At starting, the straight-flow rolling mill engine, to overcome the considerable frictional resistance of the rolls, needs, in the absence of a vacuum, very large cut-offs, at least 50 per cent, and on this account a maximum cut-off of 60 per cent was specified for these engines, which can be obtained by the very simple valve gear shown in Fig. F driven by a lateral shaft. The valves are cast together with their sites and are separated from them only during the machining process. The adjusting gear and spindle of the governor run on ball-bearings. A jet condenser (Fig. G and H) is directly coupled with the steam piston rod and therefore works with very high piston speeds. The lower the condenser pressure, the more favorable are the results on the straight flow steam engine and, therefore, it is desirable to have as high a vacuum as possible, at least 90 per cent. As very favorable experience has been had in this connection, with condensers having no suction flaps, it appeared advisable to use them also in this case notwithstanding the high piston velocities resorted to.

At first many difficulties were encountered, and only after numerous experiments could this design be fully managed. The steam is condensed in a preliminary condenser which, on account of the space requirements, is placed 2100 mm. (say 82 in.) from the center line of the main condenser. The cold water flows into it under a head of 110 in. In order that no water may run over into the steam cylinder in case of a sudden removal of the load from the engine, the piping between the condenser and engine is made 10 meters high (32.8 ft.). At first a vacuum of only 65 to 80 per cent was obtained, the variations in the vacuum being from 10 to 12 per cent. Certain leaks were discovered and eliminated in the piping, without, however, producing any satisfactory results. The preliminary condenser stood about 500 mm. (19 in.) below the main condenser. As the pipe between the two was horizontal, it was thought that the mixture of air and water did not reach the suction chamber of the main condenser in proper time, and this led to locating the preliminary condenser at a higher level so that the mixture should flow into the suction chamber with a head. No material improvement resulted. It appeared therefore that the cause of the trouble lay in the initial process occurring during the flow of the water in the S-shaped pipe and the suction room.

The water level gage was placed at the lower end of the S-pipe and it was found that in that pipe the water column varied quite considerably and irregularly, and further, that sometimes the water entirely filled the admission pipe lying immediately on the condenser. Therefore at certain positions of the water in the S-pipe the admission of air to the suction chamber of the pump was entirely cut off. It ap-

peared that this trouble might be obviated by providing the pipe R (Fig. H) with two suction valves so as to handle the air and water separately. Even that did not help entirely, however. The vacuum was made much better and rose up to 90 per cent, but the variations in the vacuum still remained at the undesirably high level of 10 to 20 per cent, and further, from time to time the pump developed a hard irregular pounding which could be softened down only by admitting air on both sides of the pump. With the new arrangement, the great variations of the water level in the S-pipe continued and evidently spread as far as the pump chamber.

As a last resort, it was decided to try the suction of air over the water level. Next, independent air suction cocks were laid at several places from the preliminary condenser to the main condenser and observations were taken to find out which of these cocks should be manipulated to produce a variation in the behavior of the pump. It was found that the nearer one approached the condenser, the better was the action of air and suction. Finally, at the highest point in the suction chamber a pipe, X, provided with a cock, was led in and the air suction taken therefrom. This had the desired result. The vacuum immediately improved and is maintained now at from 90 to 95 per cent; the variation in the vacuum comes down to only 1 per cent and the condenser runs quietly, as shown in the original article by indicator diagrams. It is quite likely that by a different arrangement

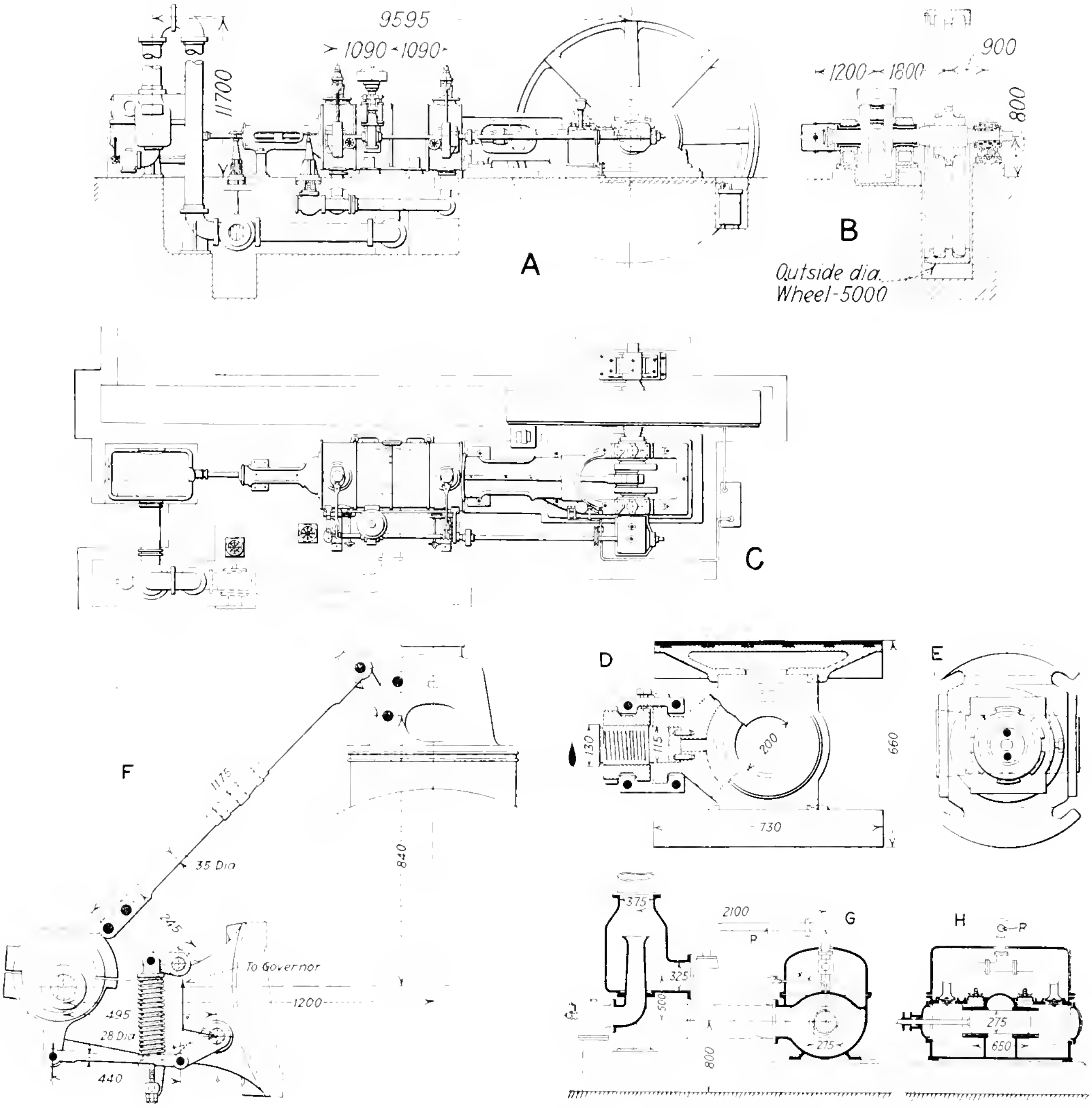
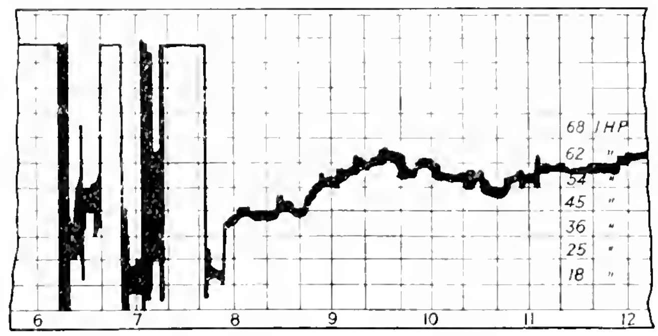


Fig. 4 Straight Flow Steam Engine for Rolling Mill Drive

of the constituent elements and by shifting the preliminary condenser closer to the main condenser, the difficulties described could have been eliminated. In the present case, however, it is interesting to know how an arrangement which apparently could have been expected to spoil the action of the mechanism, actually improved it.

Operating Tests with Indicators and Recording Load Meters (*Betriebsversuche mit Leistungszählern und registrierenden Belastungsanzeigern*, Bottcher, *Dinglers polytechnisches Journal*, vol. 329, no. 40-41, p. 593, October 10, 1914, article not finished, *de*).

The article describes the new type of Böttcher continuous load indicator and a test made with same. (Compare *The Journal*, April 1913, p. 711.) In addition to the indicator



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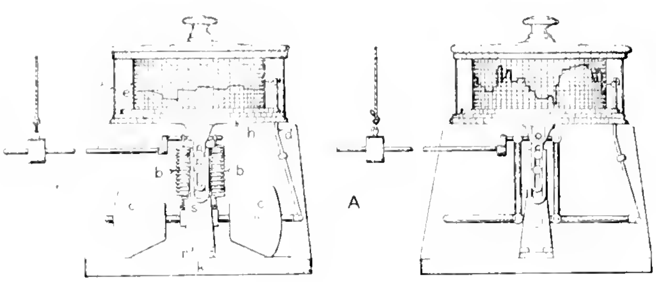

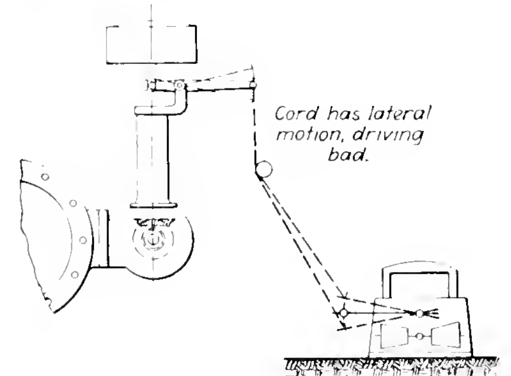

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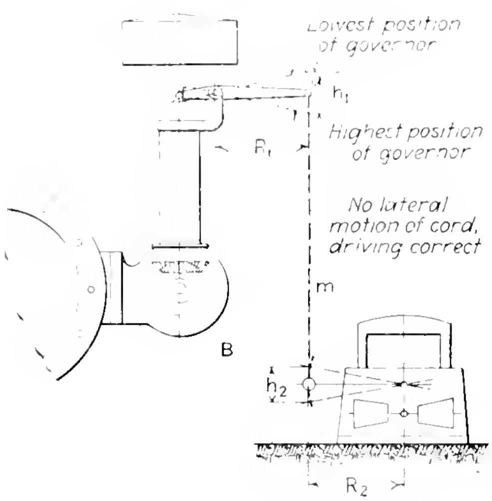

B

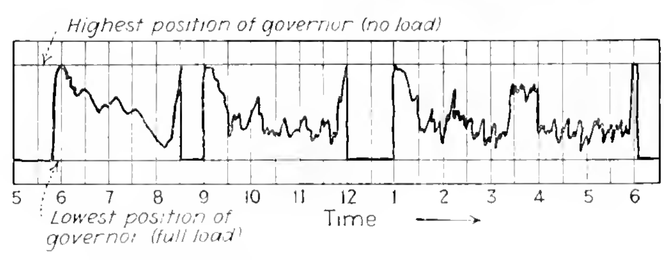

Fig. 5 Bottcher Load Indicator for Continuous Tests

described previously, a new type has lately been developed, the purpose of which is to give practically the same kind of indications as is given by the ordinary registering wattmeter in electric plants. Such an apparatus is shown in Fig. 5 A. The principle made use of in the apparatus is based on the fact that in the centrifugal governor the position of the governor sleeve regulates the operation of the engine, the lowest position giving the maximum admission and the highest position, minimum output or practically no load, each intermediate position corresponding to some output between these two extreme limits, or to a certain pressure of steam admission. The apparatus as shown in Fig. A consists, accordingly, of a balanced mass pendulum, *c*, suspended on two springs, *b*, and rotatable around the point *s*. This pendulum carries at *d* a recording pen, adjustable by means of the lever *a*. If the lever *a* is placed in its highest position, the recording pen is at its lowest point, and vice versa. The recording drum *e* is provided with clockwork and in accordance with the original design makes one revolution in 1, 12 or 24 hours. The mass pendulum begins to operate when the driving lever *a* makes small oscillations about any of its positions. These oscillations are damped out by the mass pendulum in connection with the suspension springs and in this way kept away from the recording pen. Should the engine be free from such oscillations, the mass pendulum with its spring suspension can be replaced by a simple joint parallelogram.

The connection between the governor and the engine is effected in the most simple manner by the arrangement shown in Fig. B. The position of the lever is adjusted for the machine standing still (lowest position) and for the no load run, with the admission valve open as wide as possible (highest position), and then the stroke h_1 is determined for the point of application *a*, selected for driving the apparatus. The weight of the driving lever on which the rolls for the driving cord are fixed is determined in such a manner that the stroke h_2 at its full deflection of the rod *a* be equal to the stroke h_1; the apparatus is then placed close to the engine in such a manner that the connecting cord *m* should have, as far as possible, no lateral motion, while the apparatus passes from its highest to the lowest position. Special arrangements are made only on account of the local condi-

tions, as when the cord has to be placed in an inclined position or with the possibility of lateral motion.

For the estimation of the diagrams obtained with this load indicator, it is essential to bear in mind that while the engine stands still the governor is in its lowest position. During stops, therefore, a line is drawn which coincides with the line of maximum output. Fig. C gives a typical diagram of operation of a steam engine with variable load. While during the period from 8.30 to 9 and from 12 to 1 o'clock the engine did not operate, it ran before 6 o'clock in the morning and also after 6 o'clock in the evening.

The author describes several tests made with this apparatus of which the following are outlined here: During the acceptance trials of a Diesel engine a considerable lack of regularity of operation had been observed. The test of the engines by means of a tachograph proved impossible on account of lack of space. An ordinary speed indicator showed, however, variations in the speed of rotation up to 15 per cent. With the load indicator described in this article, which could be installed without interrupting the operation of the engine, the diagram shown in Fig. D was obtained. The numbers at the bottom of the diagram indicate hours; the plans of the curve show the lowest positions of the governor, either standing still or at maximum output of the engine, while the lowest points of the curve show the engine running at no load. The engine was started at 6.15, ran for a few minutes without load and then on load up to 6.40, during which time the governor, as well as the speed of the engine, showed considerable variation, notwithstanding the constant load. The abnormal variations in the diagram clearly show this lack of regularity. In order to eliminate the fault in the engine, it was stopped for 12 minutes; the result, however, was negative, as can be seen from the diagram. At 7.18 the engine was stopped again and all parts of the governor investigated. It was found that the lever which connected the governor with the crude oil pump jammed in one position. After this fault had been eliminated the engine ran at variable load without further trouble.

The points on the load curve were very interesting where a second Diesel engine was switched in on the same transmission line. As the second engine was set for too small a speed of rotation, the first engine had to drag the second one after it, so that it was carrying an additional load to the extent of no-load on the second engine. The necessary adjustment of the second engine was materially facilitated by the indications of the speed indicator. The article is not finished.

New Patents in the Field of Boiler Firing (*Neue Patente auf dem Gebiet der Dampfkesselfeuerung*, Pradel, *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 42, p. 469, October 16, 1914, article not finished, *d*).

The article, which is not yet finished, gives a brief account of new patents granted in Germany for inventions in the field of boiler firing. The grate designed by Pellegrino Fratelli of Turin, Italy, shown in Figs. A, B and C, belongs to the class of grates with bars having longitudinal freedom of motion and automatic advance of fuel. In the neighborhood of the charging hopper in the new grate, instead of former steps, the bars are equipped with parts, such as teeth, notches, etc., on each separate bar, in order to hold the lower layer of coal during firing. In this way the front limit of the firing zone is not allowed to shift too far back. As shown in Figs. 6 A and B, the bars have a freedom of longitudinal motion in either direction in three groups, *a*, *b* and *c*. The bars of these groups are placed alternately side by side, and are located on cross-bars *d*, *e* and *f* of three driving frames, each of the frames being supplemented by a T-bar. In their turn, each of these bars is provided with cams, *k*, *l*, *m*, the purpose of which is to drive the frames and consequently the grate bars in the manner desired, from a driving shaft *n*. The bars in the proximity of the hopper are provided with a number of teeth, so as to maintain a uniform combustion over the entire surface of the grate. While the ordinary traveling grates with overlaid grate bars can move forward and backward, these two motions become impossible in the case of traveling grates with the bars rotatably located at one end and suspended at the other, since during the backward motion of the bars they would take a low position, providing they succeeded in passing under the scraper at *o*.

Thermodynamics

Specific Heat c_p of Air at 60 Deg. Cent. and 1 to 200 Atmospheres Pressure (*Die spezifische Wärme c_p der Luft*

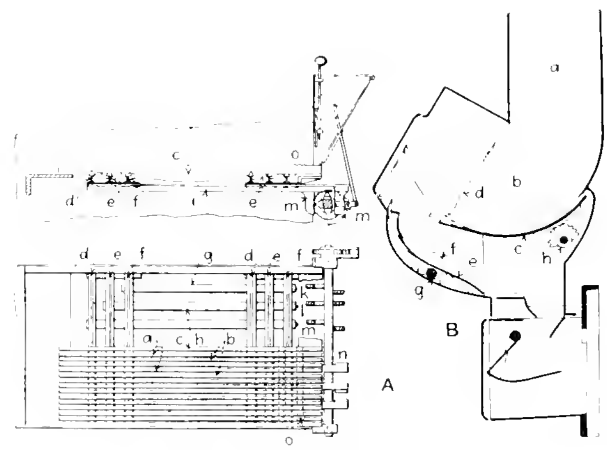

Fig. 6 Pellegrino Grate

bei 60° C und 1 bis 200 at., L. Hornborn and M. Jakob. *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 40, p. 1429, October 3, 1914, 8 pp., 16 figs. *e A*). The numerous determinations of the specific heat of air now available apply mainly to atmospheric pressure, while for higher pressures there are only a few. Regnault was the first to determine the relations between specific heat and pressure at average temperatures of from 100 to 60 deg. and pressures between 1 and 13 atmospheres, and he has established that the variation of the specific heat c_p in this region does not exceed the error of observation (1 per cent or more). On the other hand, Lussana has found that when the region of experimentation has extended up to 160 atmospheres, specific heat rises rapidly with the pressure. C. Linde has determined the increase of specific heat with pressure indirectly from the cooling at adiabatic throttling and found it to be much smaller than Lussana. The determination of this specific heat from isothermals at low temperatures made by Witkowski has also given only a slight increase in the values of c_p with the increase of pressure. In view of the fact that the data obtained in the few direct measurements of c_p at high pressures and the indirect determinations of this mag-

nitude are in flat contradiction, the State Institution of Engineering Physics (Germany) has undertaken a new direct determination of c_p at the average temperature of 60 deg. cent. and pressures from 100 to 200 atmospheres. As a method of test, the well known process of continuous flow was selected. The gas to be investigated flows in a uniform current of G kg. per hour, at constant pressure, through a calorimeter and is heated electrically, by supplying it with an amount of heat Q calories per hour, from the temperature of admission t_1 to the temperature of exit t_2. If during this process V cal. per hour are lost, then the specific heat c_p is determined from the equation,

$$c_p = \frac{Q - V}{G(t_2 - t_1)}$$

The loss V depends in this case only upon the distribution of temperature along the surface of the calorimeter. If it is always maintained equal, but at different tests the gas is permitted to flow with different velocities, then the amount G varies and several equations are obtained from which the two unknown quantities c_p and V can be calculated. For the purpose of tests only large air currents can be used, as it is desired that too much influence should not be exerted by the conduction of heat in the pipes which, on account of high pressures used, must be made with fairly thick walls. At maximum the flow of air amounted to nearly 44 kg. (96.8 lb.) per hour. Should it be reduced to one-half or one-quarter of this value, as higher precision of measurement becomes desirable, then the same distribution of temperature along the surfaces of the calorimeter can be maintained only if the pipe through which the flow occurs be surrounded by a liquid which is maintained in constant circular flow and service to equalize the temperature over the entire surface. In the present case, oil was used as such a liquid. The air entered with the temperature t_1 of about 20 deg. cent. the calorimeter and, through heat Q supplied by two electric heating bodies, was heated up to a temperature t_2 = 100 deg. cent. The oil was also maintained at this temperature. In order to make the loss V small, the entire calorimeter was surrounded by a jacket through which steam was flowing. The air G, which was allowed to expand to atmospheric pressure after the exit from the calorimeter, was measured by means of a gasometer.

New Experiments on the "Undercooling" of Saturated Steam Flowing Out of Nozzles (*Neue Versuche über die Unterkühlung beim Ausfluss gesättigtem Dampfes*, Prof. A. Stodola. *Schweizerische Bauzeitung*, vol. 64, no. 15, p. 168, October 10, 1914, 3 pp. e U). In a previous investigation the author found that when initially saturated steam flows out of a nozzle or similarly acting appliance it remains almost perfectly undercooled during the expansion up to the smallest section of the device through which the exit of the steam is effected. In the case of a nozzle at certain limits of saturation there occurs, immediately behind the smallest cross-section, a sudden increase of condensation which produces a rapid fall of undercooling.

Since then two more tests have been conducted for the purpose of elucidating this particular phenomenon. As has been explained before, for the determination of the state of end cooling in any cross-section it is necessary to know the weight of steam flowing per second G, absolute pressure p, cross-section f, and velocity of flow w. If we limit our investigation to the state in the *end* cross-section of a nozzle, the velocity of steam can be determined in the best way by measuring the jet reaction. For this purpose the author used the device suggested by Frederick and Kembel or that of Christlein, by means of which the reaction with the total capacity of about 10 kg. could be determined with an exactness of 5 gr. At the end of the nozzle, however, there may be a pressure above atmospheric about which no information is given by the reaction measurement, and the problem is raised of devising methods for the special measurement of reaction at such a relation of pressures where the steam in the end cross-section expands exactly to the back pressure of the surrounding medium. For this purpose there was placed within 3 mm. from the end of the nozzle a brass tube with well rounded inward edges 1 mm. in diameter, and the pressure in it observed through a properly placed branch tube. The pressure at the end of the nozzle could then be calculated analytically with sufficient precision. If during the test this pressure be considered as back pressure, then the measurement of reaction would indicate the desired end velocity. The nozzles investigated were of conical shape, and had at the inlet a curve of a radius equal to the diameter of the smallest cross-section.

The author has previously shown that the equation of continuity makes it necessary that the area of the end section be inversely proportional to the amount of undercooling. The data of the tests are given in Table 1. The figures of Table A raise a question how it may happen that even with perfect condensation the actually available end section does not appear to be filled up. It is true that the amount lacking appears to be very small (1.8 to 2.3 per cent), but, considering the care taken in the measurements, it cannot be due to errors of observation. One might suppose that, while the steam is saturated, *the particles of water are superheated*, and that there is therefore no uniform temperature level throughout the end cross-section; but, in order that a continuous state be maintained the temperature of the water drops, would have to be negative, or the end section would not be filled up. There must be some other explanation of this phenomenon, therefore, and the author attempts to give it in the following lines.

He starts with the investigation of what he calls the *real equation of continuity*. As a rule in engineering work, a uniform average state in a cross-section and an average velocity are presumed to exist. Actually, however, even in straight line flow only the pressure can be considered as being sufficiently uniform; the velocity decreases from the center to the walls, while the specific volume increases in the same direction due to the greater heat of friction developed in the neighborhood of the walls. Although, according to Prandtl, the main work of friction is developed within a thin layer close to the wall, while for the rest of the section a nearly adiabatic flow may be assumed, even the smallest lack of uniformity affects the equation of continuity in a very noticeable manner, and thereby the state of the steam. The author proceeds to show this. To do it, he derives a series of equations which show that, in the case of a "two-dimensional" flow the linear average value of the average velocity of flow does not agree with the square of the average value. Further, it is not correct to add the losses of flow to the average velocity of flow, but fortunately the error due to this fact does not exceed 1 per cent. The experimental work done appears to permit one to answer with a considerable degree of reliability the question as to the state of steam at the end

of the nozzle. It appears that the condensation at the end of the nozzle does not reach its theoretical value, but the undercooling is small, and inversely proportional to the amount of expansion. Further measurements could have permitted a precise formulation of the law, in accordance with which occurs the decrease along the axis of the nozzle of the almost perfect undercooling of the smallest section, but the outbreak of the European war forced the author to give this up for the time being.

TABLE 1 TESTS ON UNDERCOOLING OF STEAM. DATA CONCERNING THE TEST INSTALLATION

	Nozzle 1	Nozzle 2
Smallest diameter, mm/in.	12.06/.471	12.07/.475
End diameter, mm/in.	18/.708	25.12/.988
Distance between the smallest and the end section, mm/in.	150.5/.90	150.5/.90
Absolute initial pressure, p_1 kg/qcm, lb. per sq. in.	8.15/126	11.15/158.5
Initial temperature, deg. cent./fahr.	174/345.2	197.5/387.5
Absolute initial temperature, deg. cent.	447	470.5
Absolute end pressure of expansion, p_2 kg/qcm, lb. per sq. in.	1.082/15.32	0.571/8.11
Ratio of pressures, p_1/p_2	7.53	19.52
Specific initial volume, m³/kg, cu. ft. per lb. v_1	0.2440/3.29	0.1872/2.9
Weight of steam per second, G, kg/lb.	0.1351/0.2972	0.1809/0.3979
Coefficient of outflow x in the formula G.	2.044	2.046
Jet reaction P, kg	10.85	17.60
Average steam velocity at nozzle end, m/sec, ft. per sec.	787.7/2582	954.5/3131
Initial heat content, WE/B.t.u. per lb.	665.9/1198	675.5/1215
Initial entropy	1.6046	1.5929

A. Final state at normal expansion and theoretical condensation

	Nozzle 1	Nozzle 2
Absolute pressure, kg/qcm, lb. per sq. in.	1.082/15.32	0.571/8.11
Adiabatic heat content, WE/B.t.u. per lb.	582.6/1048	550.72/994
Adiabatic specific amount of steam	0.8930	0.8615
Adiabatic heat fall, WE/B.t.u. per lb.	83.28/150	118.3/213
Loss in per cent of adiabatic fall, per cent	11.05	8.00
Heat content of effective final state at theoretical condensation, WE/B.t.u. per lb.	591.8/1065	566.5/1019
Corresponding specific amount of steam	0.9101	0.8782
End cross-section as per equation of continuity, qcm/sq. in. f	2.498/0.385	4.842/0.740
Actual end cross-section (cold) f qcm/sq. in.	2.545/0.3937	4.955/0.767
Difference in per cent, $f - f$	1.84	2.28

ENGINEERING SOCIETIES

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Birmingham Meeting (reported from Steel and Iron, vol. 18, no. 41).

Use of Turbines for Various Purposes, F. G. Cutler (abstracted)

The Repair Department of the Modern Steel Plant, John Hulst

USE OF TURBINES FOR VARIOUS PURPOSES, F. G. Cutler (3 pp., 6 figs., *de.*). The paper describes the application of turbo-driven equipment, at the Ensley Plant, of the Tennessee Coal, Iron and Railroad Company. The author calls attention to the great reduction of power costs and savings effected by improvements in machinery, such as the installation of condensers on non-condensing units and improvements in economy by the installation of apparatus of higher efficiency, such as low or mixed pressure turbines. At the Ensley Plant, 7 years ago, there were seven boiler houses and two electric power stations of a total rated capacity of 1800 kw. and a third power station of 1800 kw. which had just been completed. All of the engines operated were non-condensing and no power was supplied to outside plants. Later, as a result of the installation of low pressure turbo-generators with condensers and cooling towers, and the installation of low pressure turbo-blowers with condensers and cooling towers at the blast-furnace blowing engine house, two boiler plants could have been dismantled entirely, one is operated only occasionally and two more at the steel plant are operated only during the time that the mills are running. At the same time, electric power is supplied to several plants in the neighborhood and to a street railway line, the result of which is the shutting down of several boiler plants and the reduction in load of others. The saving in coal with the present equipment and methods of operating over the former practice is estimated to be at the rate of 200,000 tons per annum. In one of the power houses, three 3000 kw. generators are driven by mixed pressure turbines supplied with exhaust steam through five regenerators, each 8 ft. in diameter by 51 ft. in length, from two 55 in. by 66 in. twin reversing engines. The capacity of these regenerators is sufficient to absorb the extreme fluctuations in the steam delivery without raising the back pressure on the engines over approximately 4 lb. At another power-house, three Corliss engines drive 600 kw. generators and one Corliss engine drives a 2000 kw. generator, the exhaust of these reciprocating engines being connected with a 3000 k.w. mixed pressure turbine without the regenerator, which is here eliminated on account of the relatively steady load. The turbo-blower equipment is operated by two mixed pressure turbo-blowers, each of 55,000 cu. ft. per minute capacity. One of these turbo-blowers was originally a high pressure turbine driven machine. Fairly complete steam consumption tests have been made, the principle data of which are given below. In these tests, the actual blast delivery was taken at 307.5 cu. ft. per revolution, the intermediate h.p. being based on indicator card results. The steam consumption of 2.09 lb. from 100 cu. ft. of actual blast corresponds to 18.5 lb. per indicated h.p.h. When operating non-condensing against a 2 lb. back pressure, the steam consumption per 100 cu. ft. of blast at 15 lb. is about 3 lb., corresponding to a gross saving of 30 per cent by condensing these blower engines.

The Tennessee Company was the first in this country to install turbo-blowers and exhausters in by-product work and probably the first anywhere to use them exclusively. There is a peculiar advantage in the use of turbo exhausters in the by-product service in that the centrifugal action of the blower throws out the small particles of tar fog carried with the gas, which almost eliminates the work required of the tar extractors located between the exhausters and the saturators. Of the total tar production of the plant, three per cent is recovered from the operation of the turbo exhausters. The speed and delivery of both exhausters and boosters is controlled by a float attached to the governor, the position of this float being determined by the suction pressure.

AMERICAN SOCIETY OF CIVIL ENGINEERS

Vol. 40, no. 8, October 1914.

Fundamental Principles of Public Utility Valuation, John W. Alvord

The Valuation of Public Utility Property, J. H. Gandolfo

Investigation of the Performance of a Reaction Turbine, R. L. Daugherty (abstracted)

The Differential Surge Tank, Raymond D. Johnson

Penstock and Surge-Tank Problems, Minton M. Warren

INVESTIGATION OF THE PERFORMANCE OF A REACTION TURBINE, R. L. Daugherty (18 pp., 12 figs. *eA*). This article

describes a careful and accurate test of a 550 h.p. reaction turbine recently installed at Cornell University, in which, in addition to the regular load test at constant speed, the torque, head and discharge were measured at zero speed and readings were also taken of speed, head and discharge under no load so as to obtain, approximately, a complete characteristic curve for the turbine. The turbine selected was rated at 550 h.p., at 600 r.p.m. under a head of 142 ft., had a runner 27 in. in diameter and was directly connected with a 450 kva., 2300 v., 3-phase 60-cycle alternator. The article describes in detail the method of estimating the head in a turbine test, which is a matter of agreement in any case. The rate of discharge was measured with a suppressed weir in the tail race and was computed by the modified Francis formula:

$$q = 3.33\ L\left(H + \frac{v^2}{2g}\right)^{\frac{3}{2}}$$

Where q = cu. ft. per second; L the length of crest, in ft.; H the head on weir, in ft., and v, the velocity of approach in ft. per second. If the velocity of approach is uniform over the entire cross-section of the channel, this formula is reasonably correct. In other cases, the actual velocity near the surface is much greater than the mean velocity, and then the effective velocity head is greater than that determined from the mean velocity. In the test, runs were made under various loads at the constant speed of 600 r.p.m. The turbine was also held from rotating and the torque at various gate openings was measured by a system of levers and standard weights. In addition, the turbine was permitted to turn at runaway speed, the only load on it being the friction and windage of the generator. In order to determine fully the characteristics of a turbine, however, it is necessary to test it a little above or below normal speed at various gate openings under several relations of speed to head. In the test under discussion, the head was throttled down by the gate valve to about two-thirds of its normal value and the load run was made under the regular speed of 600 r.p.m. Values of the ratio of speed to head were obtained higher than normal.

The relations between torque and speed or discharge and speed as shown by the curves in the article, are not a straight run but on a suitable scale may be represented as a fairly flat curve. From the curves showing the relation between the torque and speed or discharge and speed, the efficiency may be computed at any intermediate point and if these are the characteristics, curves may be constructed covering every possible condition under which the turbine may operate. The results are given in the form of tables and curves.

AMERICAN SOCIETY OF MARINE DRAFTSMEN

Journal, vol. 1, nos. 1 and 3, April and October 1911. Washington, D. C.

April, 1911, No. 1

U. S. Submarine Tender "Fulton," D. R. Battles

Relation of Length and Displacement to Indicated Horse Power, F. P. Knowles

Determination of the Sag of a Suspended Wire, L. H. Kenney (abstracted)

October 1911, No. 3

Designing Modern Marine Machinery, Luther D. Lovekin

The Industrial Organization of Our Navy Yards, Elliott Snow

Steam Pipe Velocities for Turbines, W. B. Robins (abstracted)

Experiments to Determine the Sag of a Suspended Wire, L. H. Kenney (3 pp., 1 fig., 1 chart, *cp*). The article describes experiments made at the Philadelphia Navy Yard to determine the sag of a suspended wire. Their purpose was to determine the amount of correction necessary in the formula for the sag of the wire and they describe in detail the apparatus used. The main element was a narrow tank about 170 ft. long, constructed for this purpose. The tensile strength of the wire was first determined and the wire was stressed during the experiment slightly below the elastic limit, so that it would not be stretched and so that no errors would be introduced in this way. The standard level for the test was gaged from the water level in the tank and as there was an evaporation loss which appreciably lowered the water level, provision for replenishing the water was made by placing three reservoirs along the sides of the tank. The data obtained from the experiment were plotted and the formula of the catenary was first applied to the result, but it was found that the curves did not conform to the formula. Then the formula of the parabola $Y^2 = 2px$ was applied and the curves were found to correspond to it, which was very fortunate since it was a comparatively simple matter to compute the sag for any desired distance from either end of support. The article gives a graphic method for obtaining all deflections from one curve, as well as the curve of deflection of wire for alignment of shafting.

Steam Pipe Velocities for Turbines, W. B. Robins (2 pp., *dp*). The article gives data on steam pipe velocities for turbines with data of steam velocities in feet per minute on United States destroyers and battle ships:

Type of Vessel	Per cent of full power	Steam per S. H. P. per hour	Steam Velocity in Feet per Minute	
			In branch from each boiler in use	In steam pipe to first turbine of series in use
T. B. Destroyer	100	14.7	5200	6090
	54	13.3	2560	6825
	11	26.6	2330	7910
T. B. Destroyer	100	12.5	7040	8245
	41	14.7	4490	11650
	8	21.5	4380	7375
T. B. Destroyer	100	14.2	6025	6300
	54	14.7	4390	9925
	11	23.3	4365	7420
T. B. Destroyer	100	14.2	5900	6165
	56	14.7	3390	10210
	11	23.0	4315	7330
T. B. Destroyer	100	14.0	6215	6500
	53	13.8	4290	9690
	10	22.5	4310	7320
T. B. Destroyer	100	14.1	5810	6075
	55	15.0	3320	8830
	12	22.5	2215	7550
T. B. Destroyer	100	15.7	5740	6010
	53	16.7	3225	8575
	11	25.6	2110	7170
Average at full power		14.2	5990	6484
Battleship	100	13.2	5740	6680
	52	14.2	3230	3760
	12	20.4	3890	1294
Battleship	100	15.0	7200	5915
	63	15.3	4610	7570
	15	25.2	3605	5925
Battleship	100	14.4	8350	6870
	66	15.1	5660	9300
	17	23.6	3370	7380
Average at full power		14.2	7097	6488

BRITISH ASSOCIATION

TEMPERATURE CYCLES IN HEAT ENGINES, Professor F. G. Coker and W. A. Scoble. The following abstract of the paper in Section G of the British Association in Australia has been taken from Gas and Oil Power, September 3, 1914, page 272, as copies of the original paper are not yet available.

Experimental investigations of the cyclical variations of heat-engines and heat-pumps have received much attention, and numerous methods and instruments have been devised to give records of their cyclical changes, such as those of pressure and volume of the working fluid, changes of angular velocity of the crankshaft, and the like. Temperature changes in the working fluid may usually be inferred very accurately from the pressures recorded on an indicator diagram, since there is usually a definite relation between pressure and temperature of a vapor as, for example, in heat-engines using steam direct from a boiler without the intervention of a superheater. In other heat-engines, such as those using superheated fluids, and also those of the internal-combustion type, the temperature is more difficult to determine, and it becomes important to measure it directly. Platinum resistance thermometers and thermo-electric couples have been frequently employed for measuring cyclical changes of temperature in heat-engines, and a complete record from point to point of a cycle may be obtained if the engine is working with absolute uniformity. As it is usually impossible to prevent some amount of variation in the working of the engine while the measurements are in progress, the resulting curve is a composite one, since each measurement corresponds to a different temperature.

The possibility of obtaining an instantaneous automatic record with an Einthoven type of galvanometer, was considered in our early experiments on the cyclical variations of temperature of the working fluid of a gas-engine, and in the walls of the cylinder, but the difficulties then appeared to be so great that a potentiometer balance method was used instead. Recently, by the kindness of the Cambridge Scientific Instrument Company, we have been able to make experiments with their latest form of short-period Einthoven galvanometer, and this has enabled us to obtain instantaneous records of the temperature-cycles of the working fluid of steam and gas-engines, and also the variations of temperature in the walls. Some of these photographic records are shown, and their detailed characteristics are considered in the paper. They confirm the general accuracy of our former measurements on cyclical variations of temperature in a gas-engine cylinder, and also show some new features due to variations from stroke to stroke caused by misfires and the like.

SEVENTH REPORT OF THE GASEOUS EXPLOSIONS COMMITTEE. The Seventh Gaseous Explosions Report presented by the Gaseous Explosion Committee of the British Association at its recent meeting in Australia is reported here from the *Gas and Oil Power* of September 3, 1913, page 274, as the official text of the report is not yet available. One of the problems requiring solution was the direct measurement of temperature of the working agent in the cylinder while the engine was running under ordinary working conditions. The difficulty of making these measurements arises from the fact that during the explosion of the charge in the engine cylinder, the temperature is sometimes higher than that of the melting point of the platinum coupling, which can be put in the cylinder to make the measurement. Professors Callendar and Dalby have devised a method shown in the article which enables direct observation of the suction temperature to be made if the engine is working not only under normal conditions, but under special conditions. During the work, the richest possible mixture is used and the temperature reached at its closure is considerably higher than that occurring in practice. The main elements of this apparatus are a platinum thermometer exposed in the cylinder and connected with a Wheatstone bridge, and a galvanometer on which the indications are received; the circuit is made by a contact maker on the crank shaft, when the crank passes through an assigned crank angle, and broken by the contact maker, when the crank passes through the second assigned crank angle, a little greater than the first, so that the thermometric measuring device is in operation during 5 deg., 10 deg. and 15 deg., as the case may be. In this way, the time between the making and breaking may be adjusted with accuracy. The temperature is measured therefore during a particular crank angle determined by the setting of the contact maker.

In this manner the mean temperature over the small crank angle can be measured at any point in the cycle, except only during the period of explosion when the thermometer is withdrawn from the cylinder. It is, however, generally desirable to measure the temperature at the point on the cycle where the rate of change of temperature is at a minimum. This point occurs just after the closing of the suction valve. The great advantage of making the measurement at this point is that the thermometer is exposed to the incoming charge during the whole of the suction stroke, and therefore the thermometer valve tends to assume the temperature of the charge. Consequently, the temperature which the small wire is set to measure does not differ greatly from the temperature of the metal in which it is mounted, which tends to minimize the errors of measurement. Elsewhere, the rate of change of temperature is greater and the error of measurement likely to be greater, owing to the lag of the thermometer. While, for example, on the expansion stroke, the temperature may vary as much as 150 deg. during the movement of the piston through one-tenth of the stroke, just after the closing of the suction valve the variation of the temperature during a similar part of the stroke is only about 20 deg.

From the temperature at one point in the cycle, that at any other point may be calculated by using the charge itself as the thermometric agent for which it is only necessary to take an indicator diagram at the time of measuring the temperature. To make this method give good results, however, it is necessary to have accurate indicator diagrams from which to measure the pressure and volume, and this leads to the development of an optical indicator.

The second method of measuring the temperature of the charge in the cylinder is by means of a couple and has been developed by Professor Coker and Mr. Scoble at the Technical College in Finsbury. It was found that alloys of platinum, rhodium and iridium were able to withstand the temperature of explosion near the walls of the cylinder for some hours and often days. Any thermo-couples, 0.0005 to 0.0008 in. thick, would do, provided the engine was not overloaded. The actual temperature measurement is then made by observing the change in the electro-motive force

produced in this couple by a change in temperature. The report describes a bridge which permits measuring with great accuracy the small changes in the electro-motive force produced by a couple of this kind.

Measurements of suction temperature were made at the City and Guilds Engineering College on a Crossley gas engine with the cylinder 7 in. in diameter, 14 in. stroke and with the compression ratio of 4.8, the object of the experiment being to show how the suction temperature varies with the speed, the jacket temperature and the mixture. The report also contains a discussion of the first law of thermodynamics and the quantity necessary to apply, to determine the heat lost and gained by the working charge during the change of state. The aim of the Committee was to ascertain the true value of the specific heat at constant volume, Kv, or in other words, to ascertain the relation between the integral energy of the gas and minimum temperature. A relation was obtained expressing the characteristic equation for gases independently of the specific heat of the gases concerned. It applies to all positions of the set point in the PV diagram, providing the two following conditions are satisfied: viz., that there is no change in the density of the gases such as may be produced by some change in its chemical constitution, and further that the weight of the working agent during the change of state is constant. Providing, therefore, that these conditions are not violated during the change of state, it is possible by means of the temperature corresponding to at least one position of the set point in the diagram, and the characteristic equation for gases, to calculate the temperature corresponding to any other position of the set point in the diagram.

CENTRAL RAILWAY CLUB

Proceedings, vol. 22, no. 4, September 1911, New York City.

Locomotive Arch Brick, George Wagstaff (24 pp., 6 figs, *dp.*). The article is devoted to the discussion of the locomotive arch brick. It takes up the whole subject from the clays used in the manufacture of the brick up to the formation of the arch brick, its moulding, drying and baking.

It is estimated that there are at the present time in the United States and Canada, about 30,000 engines equipped with fire brick arches, the majority having tube supported arches; between 7,000 and 8,000 are stud supported arches; about 3,000 oil burners and a small number have the Gaines combustion chamber. The latter apparently has quite a promising future.

The author discusses several questions often raised by locomotive engineers, such as the responsibility of the arches for the cinder banking on them; the space necessary between arch and flue sheet; the influence of arches on the leaks and ground bolts and the question of arch tubes. In the discussion which follows, the question of cinder banking, especially as affected by the design of the front end of the arch, has received a good deal of attention and data of tests of engines equipped with brick arches and those not so equipped, have been presented.

FRANKLIN INSTITUTE

Journal, vol. 178, no. 5, November 1911, Philadelphia, Pa.

Internal Stresses in Heat-Treated Axles, H. V. Wille (abstracted)

Progress in Industrial Fellowships, Raymond F. Bacon

Internal Stresses in Heat-Treated Axles, H. V. Wille (28 pp., 12 pp., *t*). The article describes a series of experiments conducted upon two 10 in. driving axles about 6 ft. long, for the purpose of determining the internal stresses in forgings after heat treatment. The axles were hollow bored with a 3 in. hole and were heated to 1500 deg. fahr., quenched in oil and then immediately removed to an annealing furnace and annealed at 1200 deg. The object of the tests was to determine the magnitude of stresses in the axles due to heat treatment. The axles were made of open hearth 0.50 per cent carbon steel with 0.037 phosphorus and 0.038 sulphur; elastic limit 51,000 lb. and tensile strength 88,500 lb. They were made from blooms of the same size and given the same reduction and number of heats in forging. Both were treated to the same temperature for quenching and drawing back and were held in the furnace the same length of time for these operations. Both were quenched in the same oil tank, the difference in treatment being the method of quenching, as one axle was lowered horizontally and the other vertically into the oil. Each axle was cut in half at the works of the manufacturer after heat treatment, one half being made into tensile test specimens and the other half reserved for these experiments. Strains were obtained by carefully measuring the specimens before and after their removal from the axles. The stresses were calculated from the measured strains. Two methods, (*a*) and (*b*), were used to obtain the strains.

Method (*a*), which was used at the Watertown arsenal some years ago by the U. S. A. Ordnance Department for the determination of strains in gun forging, is as follows: concentric rings were removed from the forgings and their diameters and thicknesses measured at several points *before* and *after* removal. From the diameters and thicknesses of the attached rings the mean diameter could be found and similarly after removal from the axle their mean diameter is again found and from the difference between these results, assuming that the rings remained circular, the strains and stresses were calculated. Generally, the mean diameters of the rings were found to be larger after removal than before, but in a number of cases this was not true, indicating that the ring did not remain circular but assumed some shape which it was not possible to follow from the measurements of diameters.

Method (*b*): A measurement of changes in length of specimens was made by means of a comparator, the measurement being done in this case by measuring the small changes in length by means of a microscope and the "standard of comparison." The measurement of a straight specimen under this method is as follows: specimens were laid out on a smoothly finished surface, and marks by means of a very fine scriber were made along the ends of a hardened steel scale of a definite length. Then a standard of comparison, slightly shorter than the steel scale and made of the same material as the specimen to be measured and shaped, was placed between the marks on the specimen. A microscope with Filar micrometer attachment was focused on the end of the specimen and the distance between each end of the standard of comparison and the marks on the test piece was measured before the specimen was cut off. In addition to the marks, perpendicularly to the axis of the specimen, a line was drawn parallel to the axis, there being also longitudinal marks on the ends of the standard of comparison which, in measuring, were placed on the longitudinal line of the specimen in order to have it always in the same position with

respect to the axis of the specimen to be measured. The length measurement was repeated after the specimen was removed. The length of the standard of comparison must of course be the same in each measurement and for this reason the standard should be made of the same material as the bar to be measured in order to avoid complications due to differences in temperature. The stresses in specimens are never distributed entirely symmetrically in the test specimens and this may cause the specimen to bend, in which case the measurement at the removal of the piece would not be entirely accurate unless means were taken to keep the specimen straight. In the present experiment, however, bending was noticed only in the longitudinal pieces cut from the inside of each axle where the results have been corrected for this condition.

The author describes in detail the process of the removal of specimens: the calibration of the Filar micrometer, and the calculation of strains. The results are given in the form of tables and curves. The average of the strains calculated show that in the case of rings, stresses produced by horizontal immersion are invariably higher than those produced by vertical immersion, the difference being approximately 10 to 15 per cent. In the case of stresses in longitudinal specimens, the stresses produced in the axles by horizontal immersion are considerably greater than those produced in vertical immersion for compression, but very much less in tension. Further, with the vertically quenched axle, the stresses are maximum near the outside surface and near the surface of the center hole, and minimum half way between these two points, while with the horizontal quenched axle, the stresses do not tend to rise to so high a maximum near the center hole. In regard to the internal stresses released in radial specimens, the plot shows that one side of the section of the axle immersed in quenching horizontally is in tension and the balance in compression whereas the stresses in the axle immersed vertically are compressive throughout the entire section.

In general, the author found that the method (*a*) does not furnish the desired results as only relative values of the mean stresses in concentric rings can be obtained and the difference in stresses in the various parts of the rings are not shown. The stress on different points of concentric rings is generally considerable and the influence of quenching in the vertically quenched axle is much greater than in the horizontally quenched axle. Heat treatment apparently has a much greater effect upon the vertically quenched than upon the horizontally quenched axle, the stresses being greater and apparently somewhat more evenly distributed in the former than in the latter. It is very possible and probable that the stresses are distributed more or less unsymmetrically throughout the length of the axle with respect to a plane perpendicular to the axis in the vertically quenched axle and with respect to the axis itself in the case of the horizontally quenched axle. In order to investigate this, it would be necessary to take specimens from both ends and the middle of the axle.

INSTITUTION OF MECHANICAL ENGINEERS

Journal, No. 2, October 1914, London.

The Discharge of Steam Through Nozzles, Dr. W. E. Fisher (abstracted)

The Theory of the Flow of Gases Through Nozzles, J. G. Stewart (will be abstracted in a future issue)

Advance Paper E (read on October 16, 1914)

Report of the Refrigeration Research Committee (abstracted)

The Discharge of Steam Through Nozzles, Dr. William E. Fisher (19 pp., 11 figs. *teA*). The present article is the second part of the paper on the discharge of steam through nozzles. It describes experiments which had for their object the measurement of the actual discharge from nozzles when the supply pressure was kept constant and the back pressure varied. Slightly superheated steam was employed, very nearly constant in temperature. The article describes the arrangement of apparatus. The nozzles at the smallest section had the diameter of 1/4 in. The results are given in the form of curves showing the discharges measured, and tables giving the figures for the discharges and also for the temperature of the steam supplied. The discharge became less when hotter steam was used. With divergent nozzles (Fig. 7 "*a*") the discharge remained practically at its maximum value until the back pressure was increased to about 0.8 of the supply pressure, or 172 lb. per sq. in. absolute. When the supply pressure was 110 lb. per sq. in., the back

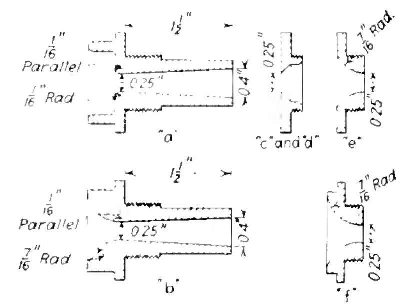

Fig. 7 Steam Nozzles

pressure was raised to 0.9 of the supply pressure before the discharge fell away to any considerable extent. Similar results were obtained with nozzle "*b*" having a 1 in 10 taper outlet and abrupt inlet. The vertical discharge as calculated from the tables of Marks and Davis was 425 lb. per hour, and this was almost exactly the measured value obtained when using the nozzle "*a*." The coefficient of discharge was therefore unity. With sharp edged orifices "*c*" and "*d*" the curves are somewhat irregular.

In tests with nozzle "*d*," which had no wire edge, the discharge, as is usual with sharp edged orifices, varied continuously with the back pressure, but there is a point at which the rate of variation of the discharge changes suddenly. It seems fair to assume that this value of the back pressure is the critical or throat pressure, since there is no chance of the overexpansion and recompression which takes place in nozzles. In nozzles without diverging parts ("*e*" and "*f*") the discharge was constant for low back pressure and began to fall away gradually at a certain point, but without discontinuity. With nozzle "*e*" (without parallel part) the first lowering of the discharge took place at a pressure of about 83 lb. per sq. in., or 0.48 of the supply pressure. With nozzle "*f*," the short parallel portion caused the point of change to rise to 100 lb. per sq. in., or 0.58 of the supply pressure. It appears that even in this short length, steam recompression takes place.

The above experiments indicate that the critical pressure is in all cases lower than the theoretical value which can be

caused by a steepening of the expansion line (on the pressure-volume diagram pressure) previous to the throat. The discharge coefficient has in no case been found to be greater than unity, and even these discharges are surprisingly high for the small size nozzles with consequent importance of skin friction and also the possibility of the stream having a true throat area smaller than the least section of the nozzle. Steepening of the expansion line corresponds to heat losses in the entry to the nozzle, but the observed fall in the critical point can hardly be accounted for by heat conducted away by the nozzle, and if the lowering of the critical pressure below the theoretical value be explained by an increase in the expansion index, it is the opinion of the author that some other physical cause for the disappearance of heat must be looked for.

REPORT OF THE REFRIGERATION RESEARCH COMMITTEE (46 pp., 16 figs., 3 sheets of charts. *g.A*). The Committee considered first what standard, if any, could be used for the practical rating of refrigerating machines. As a means of expressing the amount of refrigerating effect of which the machine is capable, under specified conditions such as occur in ordinary practice, two points are involved, viz., first, the unit in which refrigeration is to be measured and stated, and the temperatures between which a machine should, for the purpose of rating, be assumed to act; and second, the question as to what theoretical cycle of action should be adopted as a standard for comparison with the actual performance of a refrigerating machine, working under any conditions, as a means of judging how nearly the real action approaches the ideal. The following recommendations have been made:

The standard for practical rating must be based on the amount of heat extracted per unit of time and the temperatures between which the machine works as a heat pump, viz., the temperature of the source from which the heat is taken and the temperature at which the heat is discharged. It was recommended, *first*, that the refrigeration produced by a refrigerating machine be expressed in calories per second, which unit is equivalent to 342,860 B.t.u. per day of 24 hours; *second*, that refrigeration may be stated for particular or for standard conditions; *third*, that the standard conditions be defined as follows: the temperature limits to be steady; the temperature of the cooling water to range from 15 deg. cent. (59 deg. fahr.) at inlet to 20 deg. cent. (68 deg. fahr.) at outlet, and the temperature of the brine range from 0 deg. cent. (32 deg. fahr.) to —5 deg. cent. (23 deg. fahr); *fourth*, that the refrigeration produced under standard conditions be called the rated capacity of the machine. In cases of cooling by direct expansion without the use of brine, the same method of rating will apply except that the conditions have to be modified by specifying for the lower limit of temperature that of the working substance itself; *fifth*, in the rating of the direct expansion refrigerating machine, the temperature of the vapor in the evaporator be taken at —10 deg. cent. and the conditions in regard to the cooling water be the same as those laid down for the machines using brine. The temperature of —10 deg. cent. as a lower limit for the working substance harmonizes with the conditions which have been laid down for machines using brine and is also in accordance with the standard of temperatures adopted by the French Association on Refrigeration.

In regard to the theoretical cycle of compression, main attention is paid to the internal action of the working substance and the temperatures to be considered are not those external to the machine but those of the substance itself at various stages of the cycle. The theoretical performance in a vapor compression machine using any assigned working substance assumes that adiabatic compression takes place between the constant pressure limits of suction and discharge. These two pressures have to be known and also the temperature to which the working fluid may be cooled before passing the expansion valve. With these data, there will, for any working substance, be some particular degree of dryness, giving the maximum coefficient of performances in the ideal cycle. When the degree of dryness at the beginning of compression is determined, the temperature of superheating reached at the end of compression follows. The essential data, therefore, for determining the ideal cycle are the suction and discharge pressures and the temperature upon the expansion valve.

In order to secure the highest ideal efficiency, the working substance should be cooled before passing the expansion valve, to a temperature as nearly as possible equal to that of the supply of cooling water, and in calculating the ideal cycle of compression, it is proposed to take the temperature at which the cooling water is supplied as the temperature to which the working substance is supposed to be cooled before passing the expansion valve. It is recommended, therefore, *first*, that the ideal cycle to be adopted have a standard of compression with actual performance by the most efficient cycle employing adiabatic compression in which the pressures of suction and condensation are the same as those which occur in the actual process of working and in which the substance before passing the expansion is cooled to a temperature equal to that at which, in the actual process, the cooling water is supplied; *second*, that the pressures of suction and condensation referred to in the preceding recommendation for the actual process of working are to be the pressures measured just after and just before the substance passes the expansion valve. The committee does not consider it advisable to complicate the use of a standard cycle of compression by specifying an ideal cycle for the operation of refrigerating machines with compound action, i.e., those in which the compression or expansion takes place in two stages respectively. It was thought better that any actual machine employing such a compound process for the purpose of giving augmented efficiency should still have its performance compared with that of an ideal machine using the standard cycle.

The committee proposes to use the ratio of relative efficiency $\frac{C_2}{C_1}$, where C_1 is the coefficient of ideal performance found by dividing the heat taken in by the work expanded in the standard cycle and C_2 is the coefficient of actual performance found by dividing the refrigerating effect actually produced by the work expanded in driving the compressor in the real performance of the machine. It was found by direct measurement of the refrigerating effect produced in the actual work and all the work expanded, that the work may be reckoned either as the indicated work done in the compressor or as the total work required to drive it. It is important in all systems of actual performance to state clearly which of the two methods of reckoning the work was employed and, when practicable, both the indicated work and the total work to be given, stating the results of these.

The report proceeds to the discussion of the use of the vacuum I (heat contained or enthalpy) for the expansion of the state of substance at any pressure and temperature, and appends enthropy, enthalpy through for carbonic acid, with Dr. Mollier's figures, or British units of pressure and some additions based on the recent researches of Professor Jenkins and Mr. Pye. This is followed by bibliographical references to vapor available on various substances used in refrigeration. And in conclusion, the committee recommends that the council of the Institution of Mechanical Engineers should consider the desirability of authorizing them to carry out experimental researches with the object of supplying such data as are not now available regarding the physical properties of the substances used in refrigeration.

IRON AND STEEL INSTITUTE

Advance copy, autumn section 1914

The Transverse Testing of Cast Iron, George Hailstone (11 pp., 4 figs., *ec.*). The article is written with the idea of suggesting the type of cast iron test bar that should be used to obtain the most reliable and constant results with breaking load and deflection. At present, the contractor is often given an option in the specification of the test bar to be casted, viz. the bar 2 in $\times$ 1 in. section tested on 36 in. centers, or the 1 in. square bar tested on 12 in. centers. The load and deflection for each size of bar is usually stated in such cases, and it is often found that the 1 in. square bar tested on 12 in. centers is required to stand three-quarters of the load of the 2 in. $\times$ 1 in. section bar tested on 36 in. centers. The author has made a series of tests on a specially constructed testing machine, the results of which did not appear to bear out this relation. Complete data of these tests are given in tables. Indeed, the author found that the actual relation between the two English standard test bars is not 1.333 as is usually assumed, but varies only from 1.142 to 1.162 in the whole series.

To ascertain whether the skin on the test bar influences this ratio, the author made another series of tests with the bars fettled in the ordinary manner. The ratio between the two kinds of test bars was then again found to vary only from 1.134 to 1.166, or in the mean 1.146. The author comes to the conclusion that the best standard cast iron bar to give the most reliable and comparable results both in breaking load and deflection, is the one cast $2^1/_8$ by $1^1/_8$ in. in section 42 in. long, machined out to 2 in. by 1 in. in section and tested on 36 in. centers. The rate of testing should not exceed a load of 1 cwt. (112 pounds) in less than 15 seconds.

SCHOOL OF MINES

Quarterly, vol. 35, no. 3, April 1914, New York City.

Physical Properties of Steel and Cast-Iron Bars Broken at Different Temperatures, Harold Perrine and C. B. Spencer (abstracted)

Safe Eccentric Loading of Rivets, Joseph di Stasio

Physical Properties of Steel and Cast Iron Bars Broken at Different Temperatures, Harold Perrine and C. B. Spencer (19 pp., 19 plates, *he*). The article presents tests on structural metals at the temperatures which are often encountered in engineering practice. It gives a survey of previous investigations such as those of a committee of the Franklin Institute of Philadelphia, of tests made in Portsmouth dock yards, and those of Dr. Julius Kollmann, E. Howard, Fairbairn, Prof. M. Rudeloff, and Bregowsky and Spring of the laboratory of the Crane Company of Chicago.

The present investigations were carried on in the Materials Testing Laboratories of Columbia University, New York City, on apparatus designed by Prof. Ira H. Woolson. The unusual form of Rhielé testing machine of 100,000 lb. capacity was used, and the furnace to give the temperature desired was set up right in the machine. It consisted of a porcelain tube 1 ft. long and 2 in. in diameter inside, with about 25 ft. of platinum wire at $^1/_4$ in. pitch coiled around it. Fuller's earth was packed about the wire and the whole was covered with steam pipe lagging so that the entire furnace was in the form of a hollow cylinder. The temperature of the furnace was maintained by passing a current through the platinum wire and controlled quite effectively by a variable resistance placed in series with the line, permitting it being kept constant for an indefinite period. The temperature was read by a thermo-electric couple placed within the bar.

The article describes in detail the method of carrying on the experiment. The materials tested were two grades of Bessemer steel, cast iron and cast steel. The results of the tests are presented in the form of a table and a number of curves. In the case of the Bessemer steel in both grades (carbon 0.39 per cent and 0.23 per cent), the ultimate strength rose until a temperature of about 500 deg. fahr. above room temperature was reached and then it went down fairly rapidly. The elongation decreased until a temperature of about 400 deg. fahr. was reached and then it started to increase with a fair uniformity. The reduction of area in the case of the higher carbon Bessemer steel decreases until 500 deg. is reached, and in the case of the lower carbon steel, until 400 deg. fahr., then it started to rise in both cases. With cast iron a great deal of difficulty was experienced in obtaining any uniformity and it appears that the results, while accurate so far as they go, do not embrace a sufficient number of tests to determine adequately the strength of such an erratic material. The same applies to a certain extent, to the case of cast steel where the number of bars tested was insufficient. The curves tend to confirm the well-known explanation of the behavior of the metals under heat given by C. R. Roelker (*Journal of the Franklin Institute*, October 1881). Here again, it was found that the more fibrous the character of the metal, the greater is the action of heat in increasing its strength. The strength of the material is directly dependent upon the respective cohesion existing between its component molecules, and as each metal or alloy has its own definite properties and curves, this cohesion is affected by changes in temperature. Internal stresses control to a greater or less extent the shape of the curve for any particular metal alloy.

ST. LOUIS RAILWAY CLUB

Vol. 19, no. 6, October 9, 1914. St. Louis, Mo.

The Modern Tube for Locomotive Service, P. J. Conrath (12 pp., 5 figs., *gd.*). The article contains a brief historical account and general discussion of the manufacture and properties of tubes for locomotive service. The author calls attention to the fact that soft basic open hearth steel tubes withstand the treatment encountered in the process of expanding into the flue sheet better than charcoal iron. The recent application of butt welding to safe ending has the important advantage that the metal away from the weld is not so readily overheated. In tests at the laboratories of

the Norfolk & Western Railway shops, it was found that electric butt welds have 90 per cent of the strength of the material itself. In regard to the durability of the flue sheet, some of the records are remarkable: for example, on the Lehigh Valley Railroad, an engine in fast passenger service, pulling an average 450 ton train, ran a distance of 245,675 miles in 28 months on one set of lap welded "Spellerized" steel tubes. The author also gives some information about the manufacture of hot rolled seamless tubes which appear to be more durable than cold rolled tubes. He explains this fact by mentioning that the hot method will oxidize in the air, which is beneficial to the material; for while the tubes are passing from one roll to the other, hot, they are coated with oxide, which is worked into the surface of the metal by the rolls and forms a protection to the tubes, whereas when tubes are drawn cold, all of this oxide is removed while drawing through the die and the protective layer is thus eliminated.

Miscellanea

AUTOGENEOUS WELDING, PROCESS OF KELLER & KNAPPICH COMPANY (*Die autogene Schweissung nach dem Verfahren von Keller & Knappich, Rauch und Staub*, vol. 4, no. 10, p. 158, July 1914, 2 pp., 2 figs. *d.*). The article describes a portable welding apparatus designed mainly for use on repair and installation work. The whole plant can be placed on a car and thus be easily portable. It consists essentially of an acetylene apparatus, water tank, steel tank with oxygen, and oxygen pressure reducing valve. From the illustration, it appears to be fairly compact and simple.

Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

PERSONAL NOTES

Henry W. Johnson has resigned his position as mechanical superintendent of the Bullard Machine Tool Company, Bridgeport, Conn., and has accepted a position with the Russell, Burdsall and Ward Bolt and Nut Company, Port Chester, N. Y.

Frank A. Mickle has been appointed instructor of descriptive geometry and drawing at the University of Michigan, Ann Arbor, Mich. He was until recently in the employ of the Buckeye Steel Castings Company, Columbus, Ohio, as designer.

Henry W. Abbott has become associated with the Ames Plow Company, South Framingham, Mass., in the capacity of superintendent. He was formerly assistant to the master mechanic of the Pennsylvania Steel Company, Steelton, Pa.

Thomas C. Kelly has resigned his position with the Triumph Ice Machine Company, Cincinnati, Ohio, to engage in consulting engineering work in the same city.

Clarence M. Davison, formerly assistant works manager of the Alberger Pump & Condenser Company, Newburgh, N. Y., has become chief engineer of the Best Manufacturing Company, Pittsburgh, Pa.

A. H. Charles Dalley has resigned his position as Chicago Manager of the Stoker Department of the American Engineering Company to accept a position as sales manager of the Flanner Water Tube Company. Mr. Dalley has opened his headquarters in the Marquette Building, Chicago.

H. L. Seward who last year planned and developed a course for the Junior classes in both mechanical and electrical engineering at Sheffield Scientific School, Yale University in Mechanical Technology, had this year 106 students and 12 assistants in the course which began the first week in September and lasted until the opening of the Fall Term. Each student devoted 8 hours a day to the study of Manufacturing Methods and Power Plant operation in New Haven and vicinity which offers exceptional advantages for such instruction because of the many and diversified industries represented there. Over 40 local firms have coöperated with the Department of Mechanical Engineering. At the Mason Laboratory, The Brown and Sharpe Company of Providence, R. I., had in operation one of its latest 2-A Universal Milling Machines. The expert who operated the machine instructed all students in regard to its design, construction and operation. Last year new machines were exhibited by the National Acme Manufacturing Company, Cleveland, Ohio, and by the Windsor Machine Company, Windsor, Vermont.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The second regular meeting of the Armour Institute Student Branch was held on November 4. L. D. Kiley gave a talk on Patents and Patent Law. He explained the necessary requirements of a patent before it is patentable and showed some original patent papers which had been issued by the United States Government and foreign countries. He said that special stress is laid on the claims in the patent since the value of a patent lies entirely in its claims. Patent Law was dealt with very briefly because of the scope of the subject.

CARNEGIE INSTITUTE OF TECHNOLOGY

The organization meeting of the Carnegie Institute of Technology Student Branch was held on October 7. The officers for the school year are: J. R. Cline, president; B. Schwartz, vice president; C. W. Gibbs, treasurer; J. Guter, secretary. Professor Trinks, head of the Mechanical Engineering Department of the Institute, spoke on his recent trip to Europe which terminated when the war was declared. He had intended to make a study of smoke prevention and steel works engineering as taught abroad. He told of a very efficient smoke prevention society with headquarters at Hamburg. The operations of this society extend over a large part of Europe although its fees are only five dollars for membership and five dollars for each furnace. This entitles a member to at least one thorough test and possibly two each year. In his study of the teaching of steel-works engineering, he came into contact with many prominent engineers, among them Puppe, inventor of the improved mill for I-beams. Professor Trinks was impressed by the fact that air-compressors in Europe were run at about four times the speed ordinarily used in the United States. The principle of forced lubrication was the chief factor in producing this result.

CASE SCHOOL OF APPLIED SCIENCE

At a meeting of the student branch of the Case School of Applied Science on November 12, the following committees were appointed: Program Committee; Prof. F. H. Vose, chairman, A. C. Kleckner and L. K. Baker: Social Committee; C. P. Diemer, chairman, D. K. Swartwout and H. E. Wills; Publicity Committee; D. S. Stanion, chairman, and L. W. Hodous.

COLUMBIA UNIVERSITY

At a meeting of the Columbia University Student Branch on October 30, R. J. S. Pigott, Engineer of the Interborough Rapid Transit Company, gave a lecture on the Design Problems of the 59th and 74th St. Power Plants, New York City. The problems as outlined by Mr. Pigott consisted in increasing the capacity of the present stations. In the case of the 59th St. Station, the problem was met by adding low pressure turbines to operate on the exhaust steam from the reciprocating engines. In the 74th St. Station, complete turbines were substituted for the reciprocating units. These changes resulted in the reduction of the cost of power and at the same time increasing the capacity of both plants. In order to accomplish these results, mechanical stokers of the underfed type were installed which permitted the operating of the boilers at 300 per cent rated capacity.

LEHIGH UNIVERSITY

At a meeting of the Lehigh University Student Branch on October 13, a paper was read by A. F. Glass, '15, on Measurement of Large Volumes of Gases. His talk was supplemented by illustrations. Mr. Madaga, a special student at the University, discussed tests made in the U. S. Navy in this connection.

The subject of the main talk was Modern Mechanical Engineering by A. A. Shimer, '99, Chief of Service and Maintenance Department of New Jersey Zinc Company. No discussion followed.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Mechanical Engineering Society of Massachusetts Institute of Technology held its first meeting of the year Oct. 29. The meeting was a "get-together" smoker and the speaker of the evening was Mr. F. H. Fay of Boston, who gave an interesting talk on the Quequechan River Improvements which are being planned for the city of Fall River, Mass. His talk was illustrated by lantern slides, and by means of these the speaker was able to impress upon the minds of all present the decidedly unsanitary conditions which exist in the heart of Fall River due to the discharge of sewage and mill-waste into the Quequechan. Prof. E. F. Miller also spoke on the importance to all mechanical engineering students of joining the Society.

OHIO STATE UNIVERSITY

The Testing of Motor Vehicle Motors was the subject of a lecture given by Prof. F. R. Hutton before the Ohio State University Student Branch on October 16. Prof. Hutton's talk consisted of the answers to the following questions: Why test a motor vehicle? By whom should it be tested? How should it be tested? Results of test.

He pointed out the deficiencies of the road test as per-

formed by the manufacturers for advertising purposes, and declared that no two tests could be compared without considering the differences in climate, roads, tire conditions, and the personality of the driver. He emphasized the fact that a road test could not be duplicated and explained in detail the apparatus and the methods used in testing automobiles at the testing laboratories of the Automobile Club of America. In regard to the muffler, he showed that only 3 per cent more power was gained by the use of the cut-out and that about 200 per cent was deducted from the comfort of the neighborhood. The lecture was illustrated by numerous lantern slides.

At the meeting on October 30, the following papers were presented: The Buckeye-mobile, P. McC. Shafer. This was illustrated by lantern slides: The Alloy Steels, F. M. Herbst; The Layout of the Finishing Department of the Steel Casting Plant of the Gould Coupler Company, C. L. Brown.

PENNSYLVANIA STATE COLLEGE

The Pennsylvania State College Student Section of the A. S. M. E. held a meeting Oct. 29 in the Engineering Club Room, State College, with the following officers presiding: C. F. Kennedy, president; V. D. Longo, vice president; W. Blume, treasurer; D. E. Hewitt, secretary. Plans were begun for a mechanical engineering exhibit to be held at the College on Pennsylvania Day, November 13.

The attendance at the meeting was 35. No technical papers were delivered as the time was devoted to business.

RENSSELAER POLYTECHNIC INSTITUTE

The second meeting of the Rensselaer Polytechnic Institute Student Branch was held on October 29. W. S. Powers gave an interesting talk on the Power Plant of the Rochester and Syracuse Railway, located in Lyons, N. Y.

J. B. Lincoln spoke on the processes in the manufacture of woolen cloth. He showed many samples and illustrations showing the different stages of the process from the shearing of the sheep to the finished product.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch of the American Society of Mechanical Engineers held its first meeting of the school year 1914-15 on Oct. 15. Prof. F. R. Hutton, Honorary Secretary of the American Society of Mechanical Engineers and Advisory Engineer of the American Automobile Association, spoke on The Relation of the Mechanical Engineer to the Draftsman. He referred to the designing engineer, and showed how shop training of a coöperative engineering student would make him a better designer. He traced the growth of a machine from a visualization to the finished product, and showed that in each progressive step the credit and responsibility belonged to the engineer. Professor Hutton told how a draftsman could increase his value and better his position by conscientious work, and discussed in detail the liberties which an engineer and a draftsman might enjoy or expect in regard to the work he was doing for his employer. European customs were compared with those of this country, and examples cited.

UNIVERSITY OF COLORADO

A meeting of the University of Colorado Student Branch was held on November 12, at which Professor Hunter gave a talk on A Square Deal in Engineering.

UNIVERSITY OF KANSAS

The first regular meeting of the University of Kansas Student Branch was called to order by the honorary chairman, Prof Sibley. Dean P. F. Walker was elected Honorary Chairman for the year. Other officers elected were: O. T. Potter, chairman; G. A. Rathert, vice chairman; Clyde Maris, recording secretary; S. E. Campbell, treasurer, and I. W. Clark, corresponding secretary.

Dean and Mrs. Walker informally received those present after which Dean Walker gave a short talk on the American Society of Mechanical Engineers as to its purpose, membership, etc.

At a meeting held on October 15, J. E. Stillwell was elected to represent the mechanical engineers on the governing board of the "Kansas Engineer," the engineering magazine of Kansas University. Program and membership committees were appointed by O. T. Potter.

A review of the Journal for the summer months was given by I. W. Clark.

Prof. Sluss gave a talk on the use of engineering handbooks.

UNIVERSITY OF MAINE

At the meeting of the University of Maine Student Branch on November 6, the following officers were elected for the ensuing year: William L. Wark, president; Clifford A. Skillin, vice president; Harry A. Titcomb, secretary and treasurer; John A. Burke, executive committee.

At the meeting on November 12, Prof. L. B. Chapman gave a talk on Hydroplanes. Professor Chapman described the displacement boat and the gradual change from these to the hydroplanes of the present day. The talk was illustrated by lantern slides, which showed views of different hydroplane engines and of the boats themselves. A speed time chart which Professor Chapman himself had computed was shown, which gave the different speeds attained by hydroplanes up to the year 1913.

UNIVERSITY OF MICHIGAN

An open meeting of the University of Michigan Student Branch was held on October 7. The majority of the student members last year were seniors and an open meeting was held in order to arouse interest in the branch and revive the membership at least to its former number and increase it as much as possible.

Mr. Mills, chairman, outlined the purpose of the branch and the benefits derived from the lectures and from the Journal.

Mr. C. F. Hirshfeld, Chief of the Research Department of The Detroit Edison Illuminating Company, gave a talk on The Connors Creek Plant of The Detroit Edison Illuminating Company. The plant, which is not yet completed, is expected to be one of the most economical in the country. Mr. Hirshfeld showed slides illustrating the construction of the plant and then showed some of the methods by means of which the great saving of heat is to be accomplished.

UNIVERSITY OF MISSOURI

A meeting of the University of Missouri Student Branch was held on October 22. Mr. J. W. Haney, assisted by Prof. E. A. Fessenden, read a paper on Heat Transmission in Boiler Tubes, which gave an account of a series of experiments conducted at the University of Missouri Engineering Experiment Station by Mr. Haney and Professor Fessenden.

At a meeting on November 12, J. C. Squirs gave a talk on the new method of Metal Plating and Earl E. Morgan told of some of his experiences in steam turbine work.

UNIVERSITY OF NEBRASKA

At a meeting on November 10, Professor Adendorfer, a graduate of Transvaal and Cornell Universities, gave a lecture on Diamond Mining in South Africa. Professor Adendorfer is a Boer and has spent most of his time in this mining district. He discussed the development of the industry and methods of mining from the beginning up to the present time.

WASHINGTON UNIVERSITY

The following officers for the year 1914-15 were elected by the Washington University Student Branch: Prof. E. L. Ohle, honorary chairman; R. V. Henkel, chairman; W. Brotherton, vice chairman; E. C. Schisler, secretary; J. Summersby, treasurer.

WORCESTER POLYTECHNIC INSTITUTE

At the November meeting of the Worcester Polytechnic Institute Student Branch of the American Society of Mechanical Engineers, Mr. A. T. Marshall, W. P. I. '89, me-

chanical engineer for the Automatic Refrigerating Company, Hartford, Conn., demonstrated their Automatic Refrigerating Machine, one of which was in operation on the laboratory table. After a brief description of cooling processes, the speaker invited the audience to inspect the machine and a general conversation was held relative to its workings.

EMPLOYMENT BULLETIN

Note: In sending applications stamps should be enclosed for forwarding.

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

POSITIONS AVAILABLE

1035 High grade practical machine designer, experience in machine shop, pattern shop and drawing room; must be a man who can make practical designs from a shop standpoint that goods may be manufactured cheaply and be of such grade as to meet the best competition. Position permanent for man of ability. Salary according to ability. Location Missouri.

1110 Man with expert knowledge in manufacture of abrasives, emery wheels, emery cloths, etc., for position in Japan.

1111 Hustling machine shop general foreman, experienced on engine and pump work; must be a thorough mechanic, able to produce the maximum output of A-1 quality at lowest cost, and familiar with best and latest up-to-date machine shop practice. Give synopsis of experience and state age, experience, references, and compensation expected. Apply by application addressed care of Society.

1125 Draftsman or designers experienced in jig, fixtures and die work, especially those familiar with manufacture of small arms, or experience in sewing machines, typewriter work, etc. Location New York State.

1126 Progressive mechanical engineer to take charge of the mechanical department of pulp and paper mill, including a machine repair shop, also the steam and electrical equipment. Applicant must be graduate of well-known engineering school, preferably Massachusetts Institute of Technology. Prefer young man who has had a few years practical experience, if possible in pulp and paper mills. Position offers good opportunity for advancement for the right man. Give references, age, experience, education and salary expected. Location Pennsylvania.

1127 Electrical engineer for sole management of factory making economical electric lamps. Position in Petrograd, Russia. State salary wanted. Possible time of departure.

MEN AVAILABLE

L-1200 Superintendent, experienced in steam engine and general power plant operation, wishes to connect with firm owning large producer gas engine plant which is causing trouble.

L-1201 Member, technical graduate, with broad experience in the design and supervision of factory or mill buildings, power plants and machinery, purchasing materials and equipment, desires position as purchasing agent or sales engineer. Would consider position as works engineer or superintendent.

L-1202 Technical graduate, 17 years experience in sales, engineering and manufacturing in pumping and power plant machinery. Especially well equipped for position of broad responsibility in moderate sized organization.

L-1203 Member, technical graduate, age 35, shop, design, sales and management experience, wide acquaintance with manufacturers in New England and the Middle Atlantic States, and having established offices in Connecticut and Pennsylvania, desires to act as manufacturers' agent for responsible companies.

L-1204 Junior member, technical graduate, journeyman machinist with all around experience, desires position as assistant to executive in manufacturing concern or with consulting engineers.

L-1205 Member, designing and contracting engineer, practically and technically trained and having an established business acquaintance and practice, desires to add to line of affiliations as representative of first class manufacturers, preferably in the field of equipment for handling materials. Would prefer to cover northern Ohio territory.

L-1206 Junior, age 28, desires position as assistant engineer or assistant superintendent with manufacturing concern.

L-1207 Student member, University of Michigan 1914, M.E., desires position with manufacturing concern or consulting engineers. Will consider any offer with chance for advancement.

L-1208 Manufacturing superintendent or shop manager, 20 years varied experience, good organizer and executive, familiar with modern and economical manufacturing methods including any system of wage payment, expert machine demonstrator and time study man, successful in the design of special labor saving machinery and appliances for interchangeable manufacture, desires change about the first of the year.

L-1209 Member, graduate engineer, seven years experience in design and supervision of installation of mechanical equipment of buildings, power plants and central heating systems; also five years as efficiency engineer, desires position with consulting engineer, architect or private firm.

L-1210 Member, mechanical engineer and factory manager, six years in charge of drafting and designing tools and equipment for large electric plant; past eight years general manager of factory and consulting engineer developing successful registering machine and holding thirty-five patents on it, would like position with concern as mechanical engineer or factory manager. Would also consider charge of drafting room.

L-1211 Mechanical engineer, Stevens graduate, age 30, married, six and one half years varied engineering experience, at present holding responsible executive position as plant engineer with small manufacturing concern, desires similar position or one as assistant to superintendent or manager with company offering good chance for advancement. Specialty, pressed steel, both light and heavy.

L-1212 Member, sales engineer, age 27, five years experience with power plant equipment, desires sales position. At present employed.

L-1213 Associate member, technical graduate, one year teaching, four years in electric traction work including power stations economics, office routine, system and locomotive testing, three years testing and development work of large hydraulic control machinery, including testing of mechanical, electrical and hydraulic apparatus, desires position on design or experimental work in a similar line.

L-1214 Member, graduate engineer, ten years experience in responsible positions in design, construction and operation of portland cement and stone crushing plants, and especially valuable on enlargement and modernization of plants and operations, desires position. Limited knowledge of Spanish.

L-1215 Superintendent, age 39, expert in punch press work and construction of dies for sheet metal stamping and

forming. Broad experience in designing tools and labor saving devices for increasing production in interchangeable manufacturing work. Has had complete charge of plant.

L-1216 Associate-member of the A.S.M.E. and A.I.E.E., college graduate, age 34, experienced as sales engineer and a specialist in efficiency selling methods, with experience in closing large electric power contracts and as sales manager for public utility companies, is open for position with company desiring the services of a capable sales manager.

L-1217 Junior member, Worcester Polytechnic Institute graduate, M.E., age 25, two years experience in mechanical and electrical engineering, consisting of experimental and construction work in steel company.

L-1218 Technical graduate, mechanical engineer, age 31, unmarried, thorough experience in field of engineering which appertains to the multiple use of steam and vapors for boiling and heating. Broad experience in conducting experiments on a large scale, and in handling men. At present in position as designing, experimental, and erecting engineer for large corporation in the West.

L-1219 Member, Cornell graduate, 14 years experience as machinist, inspector, test engineer, draftsman, mechanical engineer, shop superintendent and salesman, with successful experience selling gas power and electric-machinery, steam specialties and gas producers, desires position as salesman or as sales department engineer. Location preferred, Northwestern or Western States. At present employed in western Canada.

L-1220 Junior, graduate mechanical and electrical engineer, experience in mechanical department of railroad in machine shop, roundhouse and office work, desires a position along similar lines with good chance for advancement. South preferred.

L-1221 Superintendent, tactful in handling men, with broad experience in modern machine shop, foundry and manufacturing practice, good designer of tools, appliances and methods for producing interchangeable work at low cost; familiar with time study and modern system of paying for labor, cost keeping, etc.

L-1222 Associate-member, graduate of M.I.T., age 27, Associate, A.I.E.E., constructing experience at M.I.T., also experience as foreman, assistant master mechanic, and assistant superintendent; past two years with Thomas A. Edison; capable of whipping new work into routine shape and presenting results in form of final reports.

L-1223 Member, 12 years practical experience, competent to organize; thoroughly familiar with all modern manufacturing methods and systems, and reducing costs, desires position as factory superintendent or foreman.

L-1224 Mechanical engineer, broad experience in design of factory and mill engineering, familiar with modern shop methods, purchasing of equipment, is open for engagement.

L-1225 Member, graduate of M.I.T., Member A.I.E.E., thorough experience in power generation and applications, ten years experience testing, designing and engineering with large electric company and public utility companies. Familiar with German, French, and Spanish, also some literary experience.

L-1226 Technical graduate M.E., three years practical experience in design, shop management, purchasing and sales work, also superintendent of company manufacturing high grade gasolene motors, would like similar position.

L-1227 Member, M.I.T. graduate in mechanical engineering with post-graduate course in electrical engineering, twenty years experience in design and construction of machinery and building, manufacturing, systematizing, accounting, refrigeration and as consulting engineer, desires permanent position with headquarters in New York.

L-1228 Member, 17 years experience, familiar with foundry and shop practice, sales engineering including correspondence and testing engineering, desires position in manufacturing concern in executive capacity, either at factory or in charge of branch office. At present employed in responsible position.

L-1229 Junior, graduate in mechanical engineering, age 29, five and one half years experience including machine shop, designing, inspecting, estimating and executive positions, desires to get into efficiency engineering work.

L-1230 Member, publicity manager, fully experienced and capable of taking entire charge of advertising department, manufacturing or selling concern, now employed by well-known corporation, wishes broader field and opportunities. New York interview requested with reliable organization wanting tangible results.

L-1231 Mechanical engineer with shop experience and 11 years thorough experience in constructing, building and maintaining various lines of plants and machinery, desires position along similar lines.

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L-1237 Member, graduate M.I.T., hydraulic and electrical engineer, age 44. Manufacturing, consulting and operating experience in this country and Germany; recently connected with some of the largest and typical hydraulic power plant installations.

ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

Air-Tank Regulations, Prescribed by the Board of Boiler Rules, Commonwealth of Massachusetts. *Boston, 1914.* Gift of John A. Stevens.

American Society of Mechanical Engineers. Condensed catalogues of mechanical equipment. vol 4, 1914. *New York, 1914.* Gift.

Bessemer, Göransson and Mushet, E. F. Lange. A Contribution to technical history. *Manchester, 1913.* Gift of author.

Brazing and Soldering, H. F. Hobart. ed. 5. *New York, 1912.*

Der Brückenbau, M. Strukel. II Teil. *Leipzig, 1913.*

Coal Gas Residuals, F. H. Wagner. *New York*, McGraw-Hill Book Co., 1914. Gift of Publisher.

Just at the present time, the problem of the utilization of coal gas residuals is attracting great attention, and this book is therefore a very timely one. The author, however, confines himself to the manufacture of tar, naphthalene, cyanogen, ammonia and benzol, which may be called the primary derivatives. The work summarizes European practice, some of which is little known in this country. W. P. C.

A Credit Union Primer. An elementary treatise on co-operative banking, containing questions and answers concerning methods of organization and operation, necessary books and forms, suggested by-laws and the credit union law of New York, A. H. Ham and L. G. Robinson. *New York, 1914.* Gift of Russell Sage Foundation.

Entwerfen von leichten Benzinmotoren insbesondere von Luftfahrzeugmotoren, O. Winkler. *Berlin, 1914.*

Le Gaz, René Masse. 3 vols. *Paris et Liége, 1914.*

Handbook for Machine Designers and Draftsmen, F. A. Halsey. *New York, 1913.*

Heat Engines, H. R. Allen and J. A. Bursley. ed. 2. *New York, 1914.*

Die Kupplungen der Walzwerke, F. Peter. *Halle a. S., 1914.*

Manual of Mechanical Drawing, J. H. Dales. Cambridge. University Press. 1914. Gift of G. P. Putnam's Sons.

A very carefully prepared manual for the beginner in mechanical drawing. Beginning with the elements of line, the student is finally led to the making of full detail drawings for an eight-inch lathe. W. P. C.

Massachusetts Public Service Commission. First Annual Report. vols. 1-2. *Boston, 1914.* Gift of Commission.

Mellon Institute of Industrial Research and School of Specific Industries. Industrial Fellowships, 1914. *Pittsburgh, 1914.* Gift of University of Pittsburgh.

Naval Reciprocating Engines and Auxiliary Machinery, J. K. Barton and H. O. Stickney. ed. 3 with plates. 2 vols. *Annapolis, 1914.*

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New York Society of Architects. Year Book, July 1914. *New York, 1914.* Gift of Society.

New York (City) Department of Bridges. Annual Report, 1913. *New York, 1913.* Gift of F. J. H. Kracke.

New York (State) Conservation Commission. Second Annual Report, 1912. *Albany, 1913.* Gift of Conservation Commission.

Nouvelles Recherches sur la Resistance de L'Air et L'Aviation with atlas, G. Eiffel. 2 vols. *Paris, 1911.* Gift of author.

The author, who is an honorary member of the A. S. M. E., describes in this book his new laboratory at Auteuil and the researches made there under conditions which permit him to keep up a work of experimentation which has been universally recognized as classical at the highest level of achievement.

The following are among the subjects treated in the present publication: graphical methods of treating problems connected with the design of planes and aeroplanes, which the author applies to the determination of equilibrium and stability of aeroplanes, moment of stability, volplaning, weight and useful power of an aeroplane, maximum of velocity for a given power, minimum power necessary to fly with a given weight. The author discusses further the problems concerning the center of gravity, vertical rudder, etc.

Chapter 3 presents a very interesting experimental investigation of the behavior of round and curved bodies with respect to air resistance, and with particular regard to shapes applicable to dirigible construction, while the rest of the book covers matters of such primary importance for aeroplane designers as wing resistance, mutual influence of superimposed planes, aeroplane construction, accessories, etc., dirigibles, pressure of air on dirigible hangars, and propellers (in connection with the latter attention is called to Note V, Concerning a Family of Propellers with Several Variable Parameters). The work is mainly of an experimental nature, and as such cannot be abstracted for a review. But it will be no exaggeration to say that its appearance marks an important step in the development of the science of aircraft design. L. G.

Ohio Public Utilities Commission. Report of Joint Committee on Valuation. 1914. Gift of L. B. Webster.

Aus der Praxis des Taylor-Systems, Rudolf Seubert. *Berlin, 1914.*

Science of Burning Liquid Fuel, W. N. Best. *New York, 1913.* Gift of author.

Skizzen und Tabellen über Hebezeuge, Georg Dreyer. *Ilmenau, 1908.* Gift of Hunt Memorial Fund.

Steam Charts, also a table of theoretical jet volocities and the Corrections of Mercury Columns with fifty illustrative problems, F. O. Ellenwood. J. Wiley & Sons, *New York, 1914.* Gift of Publishers.

A useful little book. The introduction gives a review of the fundamental notions of thermodynamics, which is followed by chapters on the preparation and use of the steam charts and tables of velocities, and on atmospheric pressures and barometric corrections: then the charts and tables, followed in their turn by a number of problems with complete solutions serving as an illustration of the instructions as to the use of the tables and charts. The charts have been plotted mainly from the steam tables of Marks and Davis. Attention is called to the way the author handles the region of very low pressures, e. g., in chart *6a* L. G.

A Suggested Extension of the Dewey Decimal System of Classification to Gas Engineering, D. S. Knauss. Written for the accounting section of the 9th annual meeting of the American Gas Institute, Oct. 1914. Gift of C. W. Rice.

Taschenbuch für Bauingenieure, Max Foerster. ed. 2. *Berlin, 1914.*

Taschenbuch für den Maschinenbau, H. Dubbel. *Berlin, 1914.*

Technische Mechanik, Ed. Autenrieth, neu bearbeitet von Max Ensslin. ed. 2. *Berlin, 1914.*

Theorie des Kreisels. Heft. 1—Die minematischen und kinetischen grundlagen der theorie. F. Klein und A. Sommerfeld. *Leipzig, 1914.*

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Wahl, Projektierung und Betrieb von Kraftanlagen. Friedrich Barth. *Berlin, 1914.*

Western Reserve University. Reports of the President and other officers, 1913-14. *Cleveland, 1914.* Gift of University.

RADIATORS AND HEAT TRANSMISSION, WITH SPECIAL REFERENCE TO PRESSED STEEL RADIATORS

Argument for Sheet Metal Radiation; efficiency and resistance to corrosion. Herbert Orr. *Metal Worker*, vol. 74, pp. 192-193, 1910. From paper read before the National District Heating Association. Pressed steel and cast iron radiators are compared.

The Relative Efficiency and Durability of Cast Iron and Pressed Steel Radiators, Ray D. Lillibridge. *Heating and Ventilating Magazine*, September 1908, pp. 33-35.

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Coefficients of Heat Transmission. John R. Allen. *Engineering Review* (N. Y.). July 1911. pp. 46-48. Coefficients of heat transmision for cast iron and wrought iron radiators. Paper read before the National District Heating Association.

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The Relative Efficiency and Durability of Different Types of Radiators. Ray D. Lillibridge. *Engineering Review* (N. Y.), August 1908, pp. 40-41. Discusses especially pressed steel radiators.

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Box, Thomas. A Practical Treatise on Heat. Ed. 5. *London-New York, Spon, 1885.*

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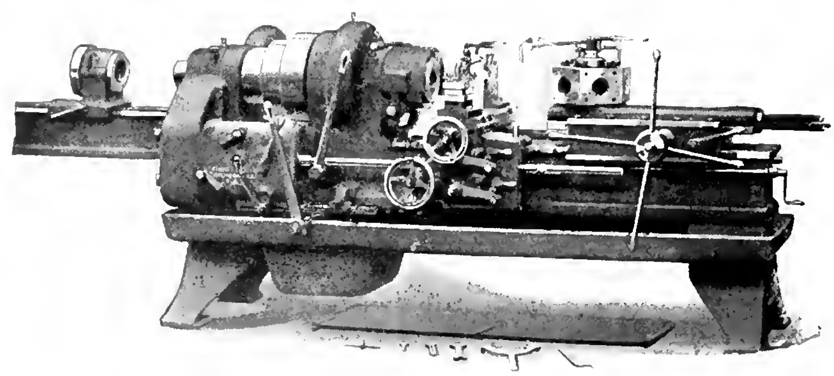

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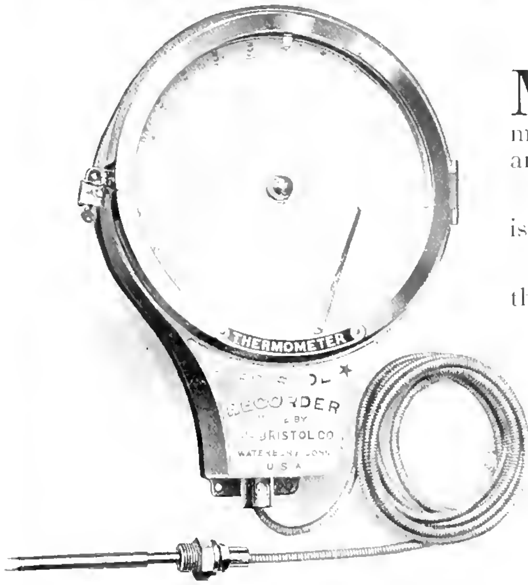

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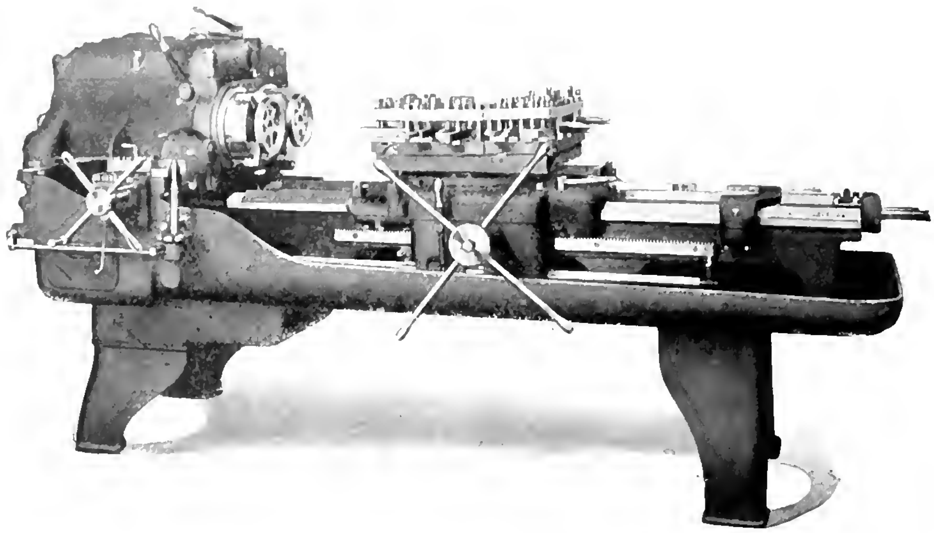

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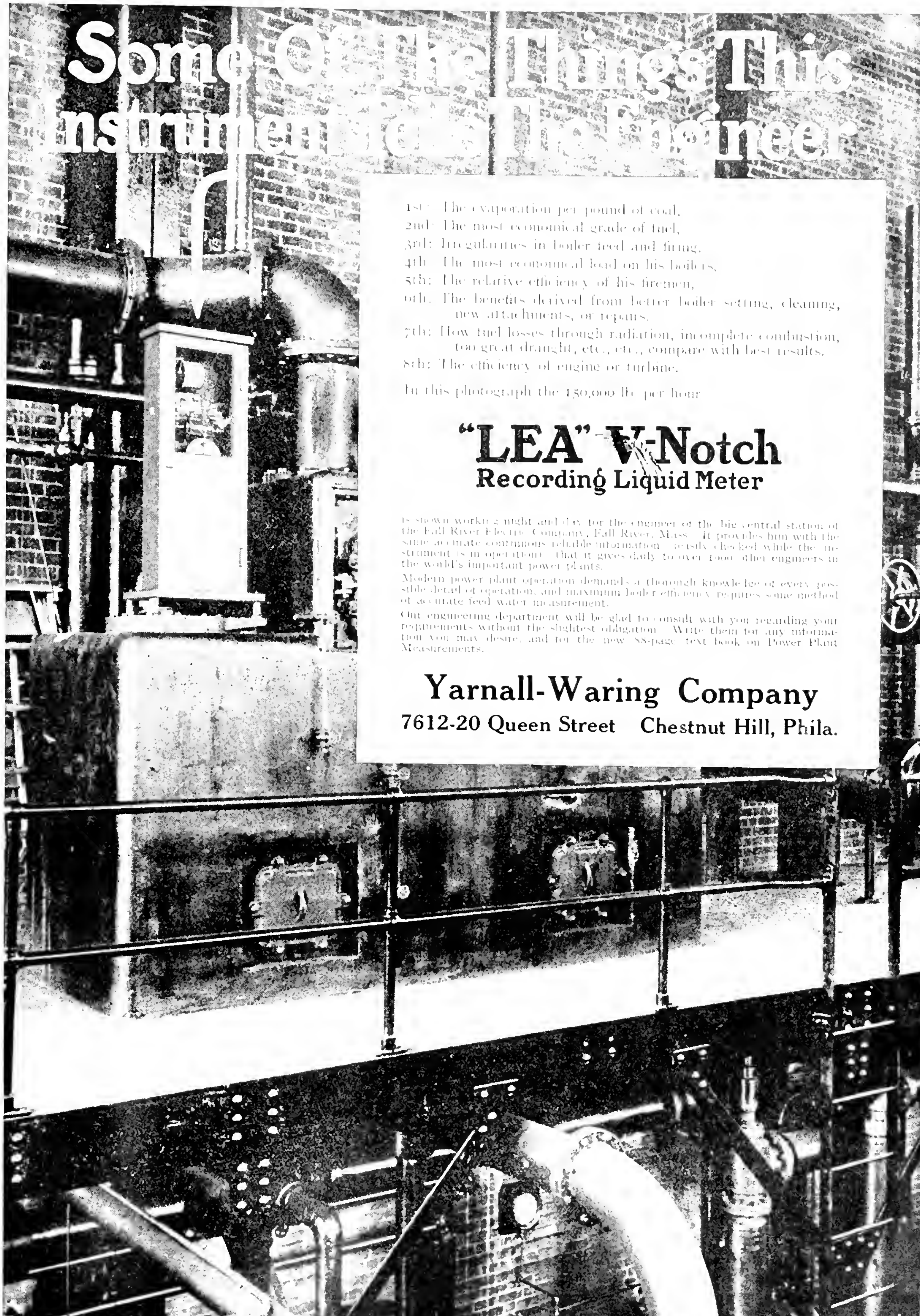
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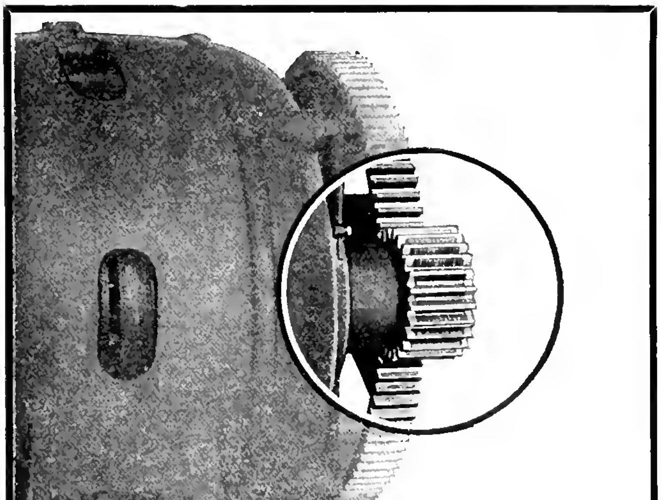

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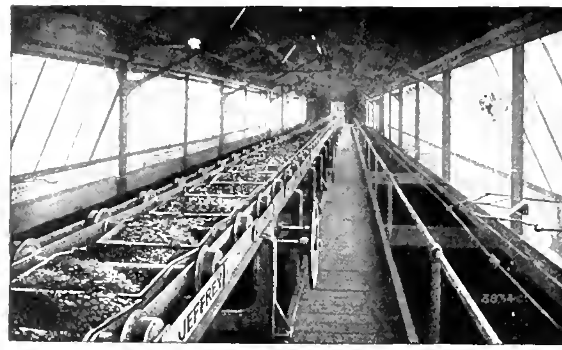

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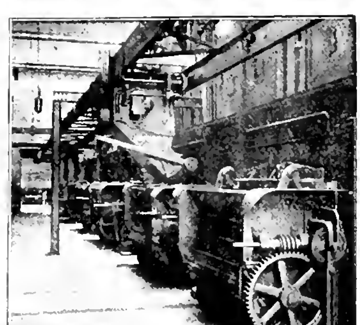

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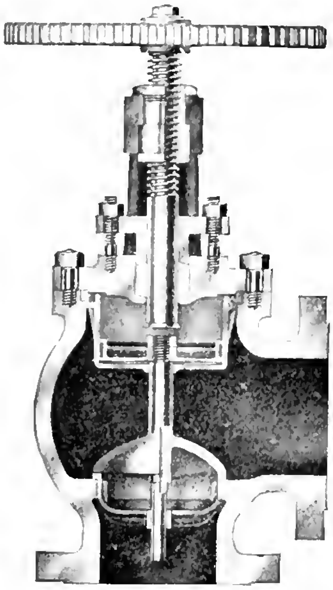

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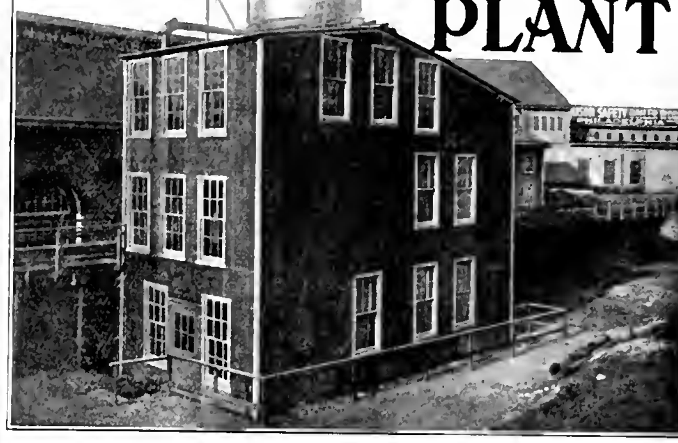

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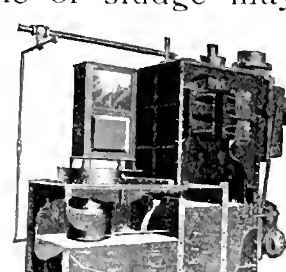

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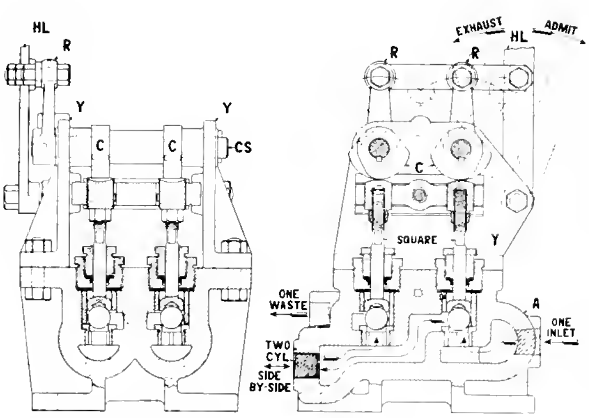

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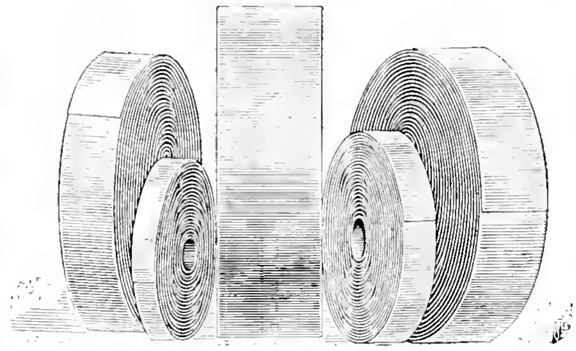

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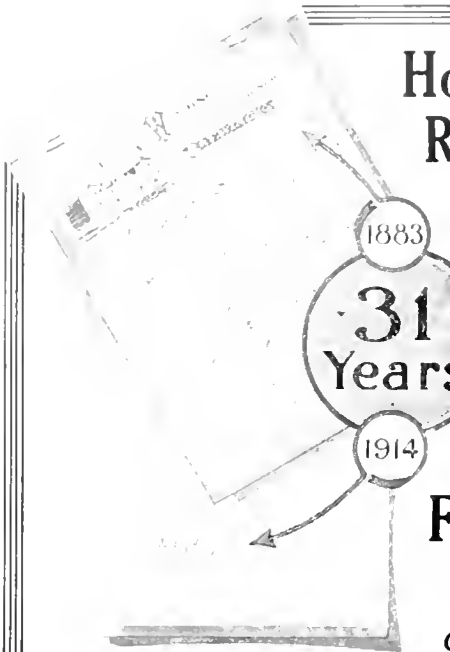


How We Retain Our Friends

A Tale of Two Contracts

IN evidence of the complete and permanent satisfaction obtained from an installation of

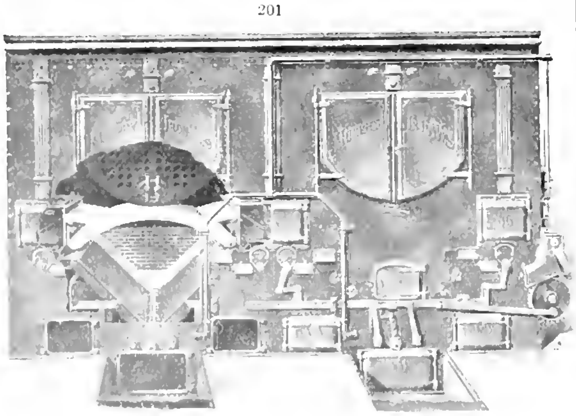
Murphy
Automatic
Furnaces

we reproduce the signature pages of two contract acceptances written thirty-one years apart—the latter covering a repeat order.

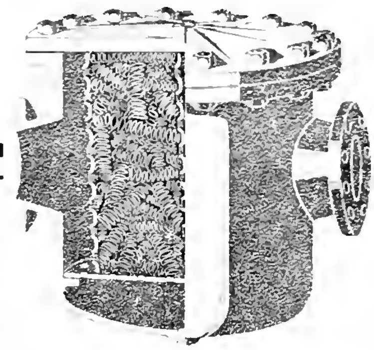
Let us tell you about this long established system of combustion. No obligations. Ask for Catalog "B."

MURPHY IRON WORKS
DETROIT MICH. U. S. A.

201



Improved Type
OIL SEPARATOR



When used in conjunction with trap and oil filter, permits the use over and over of the oil now escaping with the exhaust. It will effect a still greater saving by keeping the heating surfaces of pipe coils, feed water heater, etc., entirely free from this oil, operates without back pressure on the engine and leaves the exhaust steam, when condensed, suitable for boiler feed or manufacturing purposes.

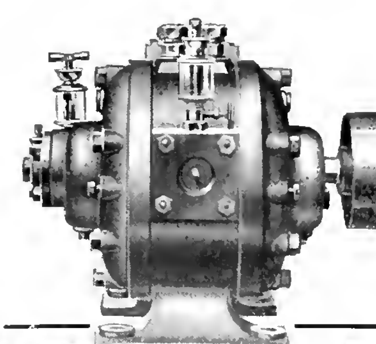
To Carry a High Vacuum
Equip your Condensers with our
ROTARY AIR PUMP

Operates with nearly 100% volumetric efficiency—clearance is practically eliminated.

The rotary piston is absolutely tight fitting to the side walls, making internal leakage impossible.

There are no valves on the suction side. On the pressure side there are only small, light check valves.

These pumps can create a vacuum up to 0.3″ mercury. They may also be used as air compressors up to 45 lbs.



GENERAL CONDENSER CO.
1250 NORTH 12TH STREET
PHILADELPHIA, PA.

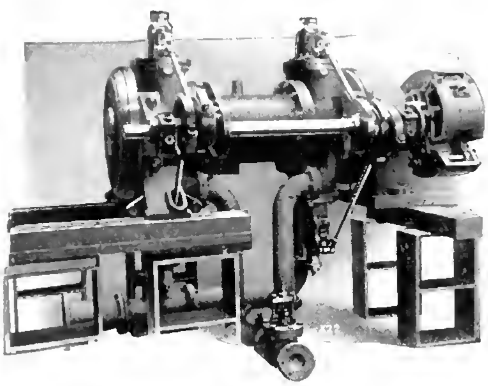
NORDBERG

POPPET VALVE ENGINES

THE cylinder and valve gear of the latest type of Nordberg high-speed Poppet Valve Engine is shown in the accompanying photograph. The cylinder is a cylindrical casting without steam or exhaust chest, separate steam and exhaust pipes being employed. The cylinder heads are cast separately from the cylinder and contain the valves, which are of the equilibrium type, with ground faces and seats. The valve cages are separate castings.

The valve gear is of a high speed design, positively operated from a revolving lay shaft, driven through bevel gears from the main shaft. An eccentric oscillates the cam which opens and closes the Poppet Valve positively without the use of springs. The governor is of the shaft type, and controls the cut-off.

Something NEW In Engines



Nordberg Poppet Valves are fitted to the ordinary (counter-flow) steam engines, to the Uniflow Engine, to blowing engines, air compressors and pumping engines. For information on Nordberg Poppet Valve Engines, send for Bulletin No. 25. Also ask for Bulletin No. 21, on Nordberg Uniflow Engines, a number of which, some with Corliss and some with Poppet Valves are now in service.

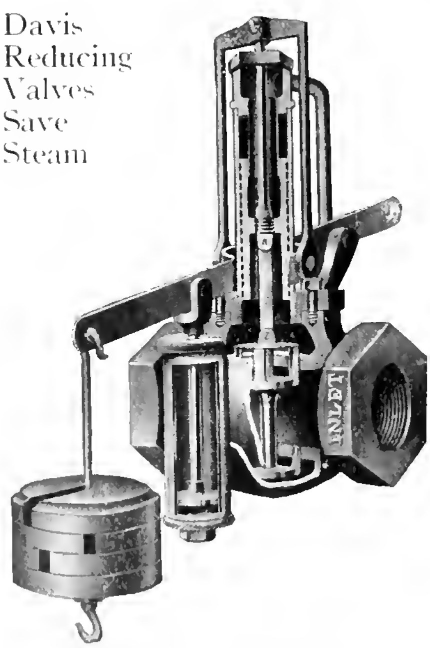
NORDBERG MFG. CO.
MILWAUKEE, WISCONSIN

Manufacturers of High Efficiency Corliss Engines; Uniflow Engines; Poppet Valve Engines; Air Compressors; Blowing Engines; Hoisting Engines; Pumping Engines; and other machinery.

NORDBERG MACHINERY

The Davis Reducing Valve

Davis Reducing Valves Save Steam



FOR automatically maintaining less than boiler pressure on your heating system, cooker, dry-kiln, pump, small engine or other apparatus, you want a Davis Reducing Valve.

This well designed, accurately made valve has a successful record of forty years back of it. It was the first good reducing valve made in this country and it is more in demand today than any other make.

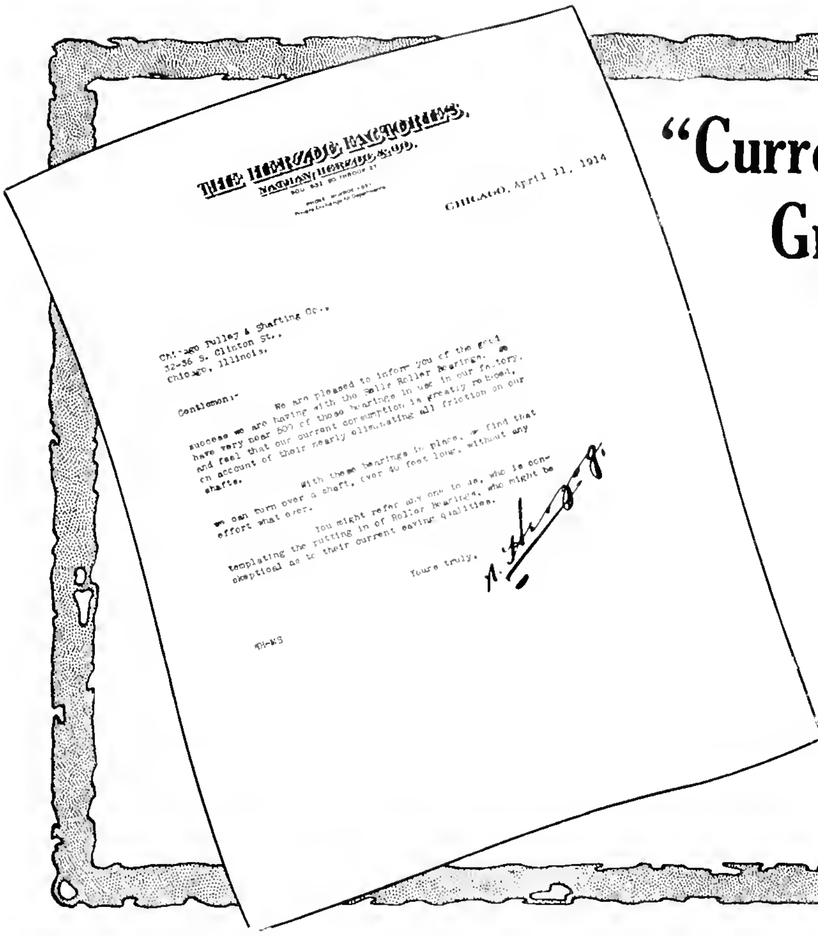
Simplicity makes for efficiency. This valve has no diaphragm, springs, toggles, packing or small ports. Its principle of operation is the balancing of pressure by counter-weights—the simplest and most dependable construction possible.

Having a perfectly balanced disk, the Davis Regulator is not affected by fluctuations in the high pressure. It will maintain a constant reduction to within a fraction of a pound, regardless of variations in the boiler pressure.

Get a Davis the next time you buy a reducing valve. It is fully guaranteed.

Send for Catalog No. 8 showing the full line of Davis Valve Specialties.

G. M. Davis Regulator Company
439 Milwaukee Ave. Chicago, Illinois
New York Boston Philadelphia Pittsburgh San Francisco


CHICAGO, April 11, 1914

Chicago Pulley & Shafting Co.,
32-36 S. Clinton St.,
Chicago, Illinois.

Gentlemen:-

We are pleased to inform you of the good success we are having with the Sells Roller Bearings. We have very near 500 of these bearings in use in our factory, and feel that our current consumption is greatly reduced, on account of their nearly eliminating all friction on our shafts.

With these bearings in place, we find that we can turn over a shaft, over 40 feet long, without any effort what ever.

You might refer any one to us, who is contemplating the putting in of Roller Bearings, who might be skeptical as to their current saving qualities.

Yours truly,

NH-MS

"Current Consumption Greatly Reduced"

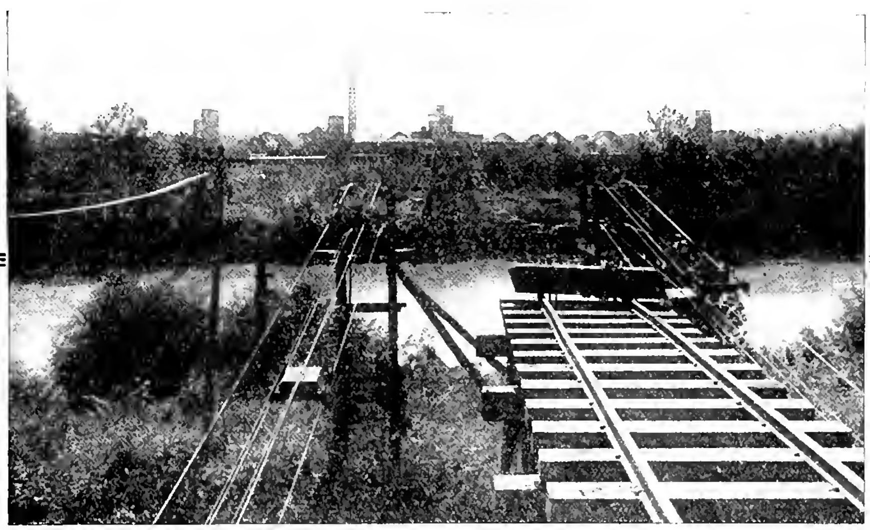
Doesn't this mean that "Sells" Roller Bearings have reduced the entire cost of manufacture? And doesn't this carry with it either a larger profit on the article or a lower selling price? In any event, it shows a way to cheaper production and distinct monetary savings.

"Sells" Roller Bearings

with *split* sleeves, *split* roller retainers and *split* boxes have made the same records as written in Mr. Herzog's letter, in the hundreds of plants in which they have been installed. Ask your machinery dealer or write us for full information. We'll be glad to send it along. Or why not write Mr. Herzog?

Power Transmission Machinery, Punches and Shears, Grinders, "Rollerine," the roller bearing lubricant.

Royersford Fdy. & Mach. Co.
60 No. 5th St., Philadelphia, Pa.



Double Tramway at the Chattahooche Brick Co.

ANNOUNCEMENT

THE Ambursen Company announces that it has this day leased for a term of years the property and plant of the **CONSOLIDATED TRAMWAY COMPANY**, of Roanoke, Va., and will hereafter operate same under the sub-title of "Tramway Department." ¶ With its seasoned Engineering and Business organization the Ambursen Company will develop as a special field all that is implied in the term "Short-haul Transportation." Where the Railroad ends, Short-haul Transportation begins. ¶ Our special line of manufacture includes not only the well-known Lawson Automatic Tramway, but also the Lawson Flexible Conveyer, the Lawson Cable-Traction Railway System, etc., etc.

Very respectfully,

November 2, 1914 **AMBURSEN COMPANY, (Tramway Dept.) 61 Broadway, N. Y.**

The Highest Development

In Very Small Indicating Instruments for Direct Current

is marked by the

Weston

Miniature Precision Instruments

MODEL 280, Single Range Portable Voltmeter
(One-quarter Size.)

PORTABLE

Volt-Meters, Millivoltmeters, Volt-Ammeters, Ammeters, Mil-Ammeters

are supplied in single, double and triple ranges, the Triple Range Volt-Ammeter comprising six instruments in one. This group also includes BATTERY TESTERS

MODEL 267, Switchboard Ammeter
(One-quarter Size.)

SWITCHBOARD

Voltmeters, Volt-Ammeters, Ammeters, Mil-Ammeters

This new line of instruments represents the finest development of small size pivoted moving coil, permanent magnet type of instruments.

They embody characteristics which have made the well-known Weston Standard famous throughout the world. They are accurate, dead beat and extremely sensitive.

They may be left continuously in circuit at full load and are shielded against external electrical and magnetic influences.

They are substantially constructed and have the longest scale ever provided in instruments of similar size.

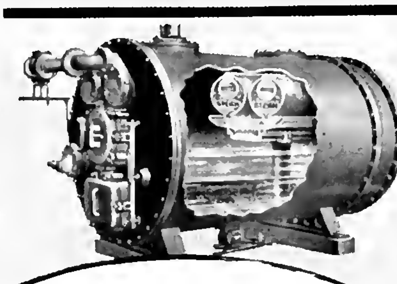
The prices are surprisingly low for instruments of such quality.

The several models and ranges, offering a selection from over 300 different combinations. They are listed in BULLETIN NO. 8, WHICH WILL BE MAILED UPON REQUEST

Weston Electrical Instrument Co., Newark, N. J.

New York	Boston	San Francisco	Atlanta	Toronto
Chicago	St. Louis	Detroit	Richmond	Berlin
Philadelphia	Denver	Cleveland	Montreal	London

NATIONAL



Direct Contact FEED WATER HEATERS Cut the High Cost of Boiling

The exhaust steam condensed becomes one-seventh of the feed water going to the boilers. One-seventh of the water bill is saved, as well as about twelve per cent. of the fuel. ¶ The unique features of the contact pipes, the evident advantages of upward filtration, and other details of the National are explained in Catalog No. 2—send for it.

The National Pipe Bending Co.
New Haven, Conn. 46-76

A BOILER SETTING *lined entirely* with Betson Plastic Fire Brick is Gas and Air tight.

Fuel losses, as high as 25% of the fuel consumption, have been proven to be due to the uncontrollable air leakage through cracked or faulty boiler setting.

This means money and why not let us help you to save it? Temporarily by patching up the holes and cracks; permanently with a new One-piece lining of Betson Plastic Fire Brick.

Betson Plastic Fire Brick Co.

Box 7312, Rome, N. Y.

C. H. Wheeler Condensers

We guarantee our apparatus to maintain a vacuum as close to absolute as is commercially possible, and with the lowest operating and maintenance cost.

The C. H. WHEELER "High Efficiency" System of Steam Auxiliaries includes:

- **C. H. WHEELER** High Transmission Surface Condensers.
- **C. H. WHEELER** Counter Current Central Barometric; and High Vacuum Low Level Jet Condensers.
- **C. H. WHEELER-PRATT "ROTREX"** Patent Vacuum Pumps.
- **C. H. WHEELER-MULLAN** Patent Vacuum Pumps.
- **C. H. WHEELER-THYSSEN** Hydraulic Entrainment Type High-Speed Vacuum Pumps.
- **C. H. WHEELER IMPROVED** Rotative Dry Vacuum Pumps.
- **C. H. WHEELER** Centrifugal Pumping Machinery, all capacities. Belt, Engine, Turbine or Motor driven.
- **C. H. WHEELER-PRATT** Water Cooling Apparatus. Forced and Natural Draft designs. Sold on efficiency, durability and low maintenance guarantees.
- **C. H. WHEELER** Improved Closed Feed Water Heaters for primary or auxiliary service.
- **C. H. WHEELER** Vertical Enclosed Self-Lubricating Engines.
- **C. H. WHEELER** Atmospheric Exhaust Valves.
- Multiflex Automatic Relief Valves.
- Expansion Joints.

"Everything but the Turbine"

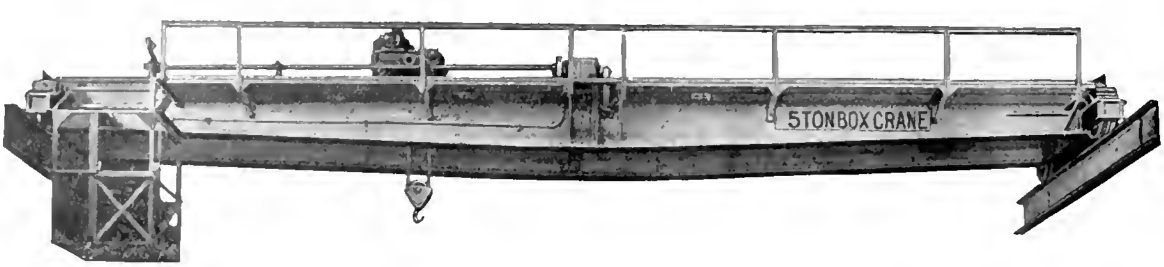
C. H. WHEELER MANUFACTURING CO.

PHILADELPHIA, PENNA.

BRANCHES

New York	Pittsburgh	Chicago	San Francisco	New Orleans
Boston	Cleveland	Cincinnati	Charlotte	Honolulu T. H.

ELECTRIC & HAND POWER CRANES, PORTABLE ELECTRIC & MONORAIL HOISTS



ALFRED BOX & CO., PHILADELPHIA, PA.

The Position of the Operator

cannot be improved either for firing the boiler or view of the load and is entirely unobstructed by piping, boom latticing or other obstructions. Another evidence that the designs of

O. S. LOCOMOTIVE CRANES

are the most "up-to-date" on the market and are the result of many years of experience in the design, manufacture and operation of such equipment.

They have been made the standard of many large railroads and other corporations and their popularity is evidenced by a demand for them which has always taxed our producing capacity to the utmost.

ORTON & STEINBRENNER CO.

Main Office: CHICAGO, ILL. Works: HUNTINGDON, IND.

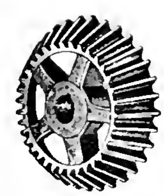
THE A. & F. BROWN CO.

ENGINEERS, FOUNDERS, MACHINISTS AND MILLWRIGHTS

Friction Clutch Pulleys and Couplings

POWER TRANSMISSION MACHINERY

DESIGNED, FURNISHED AND ERECTED



Gears of all kinds and sizes

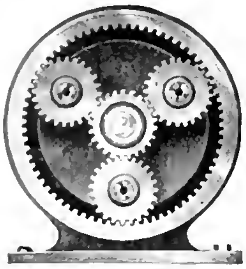
SPECIAL MACHINERY IRON CASTINGS

WORKS: ELIZABETHPORT
NEW JERSEY

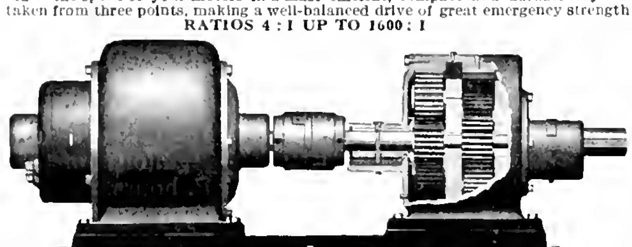
SALES ROOM: 79 BARCLAY ST.
NEW YORK CITY

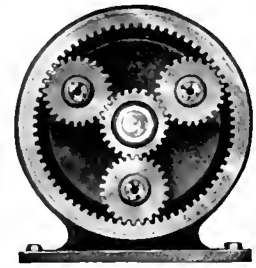
O. K. SPEED REDUCING TRANSMISSIONS

Will reduce the speed of your motors in a most efficient, compact and durable way Power is taken from three points, making a well-balanced drive of great emergency strength
RATIOS 4 : 1 UP TO 1600 : 1



O. K. Speed Reducing Transmissions meet the demands for a reliable and efficient method for reducing the motor speed without the use of belts or chains





The O. K. Reducer is enclosed, which positively eliminates all chances of dirt or dust getting in the working parts, and leaves no gears exposed to injure the workman.

SEND FOR BULLETIN No. 5

D. O. JAMES MFG. CO. 1122 West Monroe St., Chicago

Established 1888

SPECIALISTS IN CUT GEARING

POWER PLANT EQUIPMENT

ALMY WATER TUBE BOILER CO.

PROVIDENCE, R. I.

Manufacturers of Almy Patent Sectional Water Tube Boilers for steamships, river steamers, both propeller and stern wheel, torpedo boats, fire boats, launches. Donkey Boilers for steamships and for all kinds of stationary work.

Water Tube Boilers

AMERICAN STEAM GAUGE AND VALVE MFG. CO.

BOSTON, MASS. ESTABLISHED 1851

Pressure and Recording Gauges, Engine Room Clocks and Counters for all purposes. Iron and Brass Pop Safety and Relief Valves for stationary, marine and locomotive use. The American Thompson Improved Indicator with new improved detent motion. The American Ideal Steam Trap.

See pages 110, 111 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume*.

Valves

Gauges

Indicators

W. N. BEST

11 BROADWAY NEW YORK CITY

Apparatus for and technical information relative to all forms of liquid fuel equipment.

Oil and Tar Burners

Furnaces

CHAPMAN VALVE MANUFACTURING CO.

INDIAN ORCHARD, MASS.

BOSTON NEW YORK ST LOUIS PITTSBURGH CHICAGO PHILADELPHIA SAN FRANCISCO

Brass and Iron Valves for steam, water, gas, oil, etc. Sluice Gates. Send for catalogue.

See page 76 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume*

Valves

CRESCENT MANUFACTURING CO.

SCOTTDALE, PA

Lackawanna Sight Feed Lubricators and Automatic Grease Cups

Lubricators

Grease Cups

EDGE MOOR IRON COMPANY

EDGE MOOR, DELAWARE

Builders of the Edge Moor Water Tube Boiler. Especially suitable for large power plants. Steel construction, straight tubes, all hand holes elliptical, unrestricted circulation which permits forcing fires with safety and economy.

See page 23 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume*.

Water Tube Boilers

ERIE CITY IRON WORKS

ERIE, PA

Boilers: water tube, horizontal tubular, return tubular, water bottom portable, open bottom portable, vertical tubular and vertical water tube. Engines: Erie City "Lentz," four valve, enclosed high speed, automatic, center crank, side crank, portable and Feed-Water Heaters from 25 to 600 h.p.

Steam Boilers and Engines

Feed-Water Heaters

HARRISBURG FOUNDRY & MACHINE WORKS

HARRISBURG, PA

Manufacturers of Fleming-Harrisburg Horizontal Engines, Corliss and Single Valve, Simple, Tandem and Cross Compound.

Steam Engines

HOMESTEAD VALVE MANUFACTURING CO.

WORKS: HOMESTEAD PA
PITTSBURG PA

Manufacturers of "Homestead Valves." Straightway, Three-way and Four-way, for blow-off or for highest pressure and most difficult service for water, air or steam. Valves unlike all others.

See page 82 *of Condensed Catalogues of Mechanical Equipment*, 1913 *Volume*.

Valves

POWER TRANSMISSION
HOISTING AND CONVEYING MACHINERY

Cranes

THE MORGAN ENGINEERING CO. — ALLIANCE, OHIO

Are the largest builders of Electric Traveling Cranes in the world. We also design and build Steel Plants complete, Hammers, Presses, Shears, Charging Machines and all kinds of Rolling Mill and Special Machinery.

Robins Belt Conveyors

ROBINS CONVEYING BELT COMPANY — 13 Park Row, NEW YORK

The Robins Belt Conveyor was the original and is today the standard of this type of conveying machinery. It is successfully and economically conveying ore, rock, coal and similar materials under the most trying conditions of service. Correspondence invited.

See page 193 of Condensed Catalogues of Mechanical Equipment, 1913 Volume

Pulleys

Paper Friction Transmission

THE ROCKWOOD MANUFACTURING CO. — 1925 English Ave., INDIANAPOLIS, IND.

Rockwood Paper Frictions have proven their unquestioned superiority. You will find our booklets regarding Transmission of Power by Belts and Friction Transmission desirable additions to your engineering library. Furnished free to members upon application.

Cranes

Mono-Rail Systems

SHAW ELECTRIC CRANE CO. — MUSKEGON, MICH.

Address 119 W. 40th St., New York, (*See Manning, Maxwell & Moore, Inc.*)

Electric traveling Cranes for all purposes. Gantry Cranes. Wharf Cranes and Winches. Mono-Rail Systems.

Cranes

Hoists

THE TOLEDO BRIDGE & CRANE CO. — TOLEDO, OHIO

Toledo Cranes and Hoists; Coal and Ore Handling Bridges; Grab Bucket Machinery; Electric and Hand Power Cranes, all types, any capacity; Structural Steel for Factory Buildings.

Elevating

Conveying

Power Transmitting Machinery

THE WEBSTER M'F'G COMPANY — (Successors to WEBSTER M'F'G CO.) TIFFIN, OHIO; Eastern Branch, 88-90 Reade St., NEW YORK

Manufacturers of Elevating, Conveying and Power Transmitting Machinery for all purposes. Over thirty years' experience in this line and extensive facilities for manufacturing give us large advantages. Belt Conveyors for handling cements, ores, sand, gravel, etc. Coal and Ash Handling Systems for power plants and buildings. Chain belting. Gearing.

Power Transmission

T. B. WOOD'S SONS CO. — CHAMBERSBURG, PA.

Modern and Approved Appliances for the transmission of Power. Shafting, Couplings, Collars, Hangers, Pulleys, Belt Tighteners, Friction Clutches, Rope Driving Equipments.

See pages 151, 155 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

STEEL WORKS AND ROLLING MILL EQUIPMENT

Engines

Rolling Mill Machinery

MACKINTOSH, HEMPHILL & CO. — PITTSBURGH, PA.

Engines, single and compound, Corliss reversing and blowing. Rolling Mill and Hydraulic Machinery of all kinds. Shears, Punches, Saws, Coping Machines.

Blast Furnace Blowing Engines

WEIMER MACHINE WORKS COMPANY — LEBANON, PA.

Builders of Blast Furnace Blowing engines and equipments. Cinder and hot metal cars. Furnace Bells and Hoppers. Rolling Mill castings. Special attention paid to quick repair work and work governed by Engineers' specifications.

PUMPS AND HYDRAULIC TURBINES

Pumps

Condensers

M. T. DAVIDSON CO.

43–53 Keap St. BROOKLYN, N. Y.
New York, 154 N[illegible]
Boston, 300 [illegible] St.

High grade economical Pumps for all services. Surface and Jet Condensers.

Water Wheels

Wood Pulp and Paper Machinery

HOLYOKE MACHINE COMPANY

HOLYOKE, MASS.
WORCESTER, MASS.

Water Wheels with Connections and Complete Power Transmission, Water Wheel Governors, Gearing, Wood Pulp and Paper Machinery, Pumps, Hydraulic Presses. Special Machinery to order.

Turbines

Paper Mill Machinery

J. & W. JOLLY, Inc.

HOLYOKE, MASS.

McCormick Holyoke Turbines designed to suit Mill or Hydro-Electric Work. Paper Mill Machinery, Shafting, Gearing, Pulleys and Freight Elevators.

See page 298 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Vacuum Pumps

LAMMERT & MANN

215–221 N. Wood St. CHICAGO, ILL.

Engineers and Machinists.
Manufacturers of Rotary Vacuum Pumps for highest dry vacuum, Lead Pumps, Rotary Blowers, etc.

ELECTRICAL APPARATUS, ENGINEERING MISCELLANY

Aluminum

ALUMINUM COMPANY OF AMERICA

PITTSBURGH, PA.

Aluminum Ingot, Sheet, Rod, Wire, Cable, Tubing and other forms.

See page 267 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Water Purifying Machinery

ELECTRIC WATER STERILIZER CO.

SCOTTDALE, PA.

Manufacturers of Electrical and Mechanical Water Purifying Machinery. Our Electric Water Sterilizing Machine is both economical in consumption of electric current and so simple that any one of average intelligence can take care of it. Guaranteed to deliver pure water. Capacities of stock machines from 10 to 1000 gallons per hour.

Bright Cold Finished Steel Bars

UNION DRAWN STEEL CO.

BEAVER FALLS, PA.

Makers of Bright Cold Finished Bessemer, Open Hearth Crucible and Alloy Steels, in Rounds, Flats, Squares, Hexagons and Special Shapes.

See page 263 of Condensed Catalogues of Mechanical Equipment, 1913 Volume.

Dynamos

Motors

Transformers

Instruments

WAGNER ELECTRIC MANUFACTURING COMPANY

ST. LOUIS, MO.

Single-Phase Motors. Polyphase Motors. Transformers, Power and Pole Type. Instruments, a complete line. A. C. Generators. Converters for charging vehicle batteries from A. C. Rectifiers for charging small storage batteries from A. C. Train Lighting (Electric) Equipments. Automobile Self Starters (Electric), etc.

CLASSIFIED LIST OF MECHANICAL EQUIPMENT

Manufactured by Firms Represented in The Journal of The American Society of Mechanical Engineers

Accumulators, Hydraulic
* Alliance Machine Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Engineering Co.
* Wood & Co., R. D.

Aerial Tramways
(See Tramways, Wire Rope)

Air Brakes, Compressors, Filters, Receivers, etc.
(See Brakes, Compressors, Filters, Receivers, etc., Air)

Air-Jet Lifts
Schutte & Koerting Co.

Air Lift Pumping Systems
* Ingersoll-Rand Co.

Air Washers
General Condenser Co.
* Sturtevant Co., B. F.

Alloys
* Aluminum Co. of America

Alternators
(See Generators, Electric)

Aluminum, Ingot
* Aluminum Co. of America

Aluminum, Sheet
* Aluminum Co. of America

Ammeters, Voltmeters
(See Electrical Instruments)

Ammonia Condensers, Fittings, etc.
(See Condensers, Fittings, etc., Ammonia)

Anvil Blocks
* Hooven, Owens, Rentschler Co.

Arc Lamps
(See Lamps, Arc)

Arches, Ignition (Flat Suspended)
Green Engineering Co.

Asbestos Products
* Keasbey Co., Robt. A.

Ash Ejectors
(See Ejectors, Ash)

Augers, Power Coal
Fairmont Mining Mach. Co.

Balanced Main Valves
(See Valves, Balanced Distribution)

Barometers
* Tagliabue Mfg. Co., C. J.

Ball Bearings
(See Bearings, Ball)

Balls, Brass and Bronze
* Auburn Ball Bearing Co.

Balls, Steel
* Auburn Ball Bearing Co.

Barrels, Tumbling
Royersford Foundry & Machine Co.

Barrows, Furnace Charging
Weimer Machine Works Co.

Bearings, Ball
* Auburn Ball Bearing Co.
Fafnir Bearing Co.

Bearings, Roller
Royersford Foundry & Machine Co.

Bearings, Self-Oiling
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
Dodge Mfg. Co.
Doehler Die-Casting Co.
* Falls Clutch & Machinery Co.
Franklin Manufacturing Co.
* Hill Clutch Co.
Jeffrey Manufacturing Co.
Royersford Foundry & Machine Co.
Webster Mfg. Co.
Wood's Sons Co., T. B.

Bearings, Thrust
* Auburn Ball Bearing Co.
Fafnir Bearing Co.
* Hill Clutch Co.

Bells and Hoppers, Furnace
Weimer Machine Works Co.

Belt Dressing
Schieren Co., Chas. A.
* Texas Co.

Belt Lacing
Schieren Co., Chas. A.
Williams & Sons, I. B.

Belt Lacing, Steel
Bristol Co.

Belt Tighteners
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
Dodge Mfg. Co.
* Hill Clutch Co.
Webster Mfg. Co.
Wood's Sons Co., T. B.

Belting, Chain
(See Chains and Chain Links)

Belting, Conveyor
* Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.
* Robins Conveying Belt Co.

Belting, Rubber
* Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.

Belting, Leather
Schieren Co., Chas. A.
Williams & Sons, I. B.

Belting, Textile
* Goodrich Co., B. F.

Bending Machines, Hydraulic
Morgan Engineering Co.
* Wood & Co., R. D.

Bins, Suspended
Brown Hoisting Machinery Co.

Blocks, Tackle
* Clyde Iron Works
* Hunt Co., Inc., C. W.
* Roebling's Sons Co., John A.

Blowers, Centrifugal
* General Electric Co.

Blowers, Fan
Green Fuel Economizer Co.
* Sturtevant Co., B. F.

Blowers, Pressure
Lammert & Mann
* Roots Co., P. H. & F. M.
* Sturtevant Co., B. F.

Blowers, Rotary
Lammert & Mann
* Roots Co., P. H. & F. M.
Schutte & Koerting Co.

Blowers, Soot
Simonds & Co., G. L.

Blowers, Steam
Schutte & Koerting Co.

Boiler Coverings, Furnaces, Tube Cleaners, Tubes, etc.
(See Coverings, Furnaces, Tube Cleaners, Tubes, etc., Boiler)

Boilers, Heating
* Keeler Co., E.
* Smith Co., H. B.

Boilers, Locomotive
* Clyde Iron Works
Erie City Iron Works
Lidgerwood Mfg. Co.

Boilers, Marine
* Almy Water Tube Boiler Co.
Babcock & Wilcox Co.
* Keeler Co., E.

Boilers, Range (Galvanized)
Scaife & Sons Co., Wm. B.

Boilers, Tubular
* Clyde Iron Works
Erie City Iron Works
* Keeler Co., E.
Lidgerwood Mfg. Co.

Boilers, Water Tube
* Almy Water Tube Boiler Co.
Babcock & Wilcox Co.
* Edge Moor Iron Co.
Erie City Iron Works
Heine Safety Boiler Co.
* Keeler Co., E.

Bolt-Cutting Machines
Wells Bros. Co.

Boring and Drilling Machines
Manning, Maxwell & Moore, Inc.

Boring and Turning Mills, Vertical
King Machine Tool Co.

Brass-Working Machine Tools
(See Tools, Brass-working Machine)

Brewers' and Bottlers' Machinery
Vilter Mfg. Co.

Brick, Fire
* Betson Plastic Fire Brick Co.

Bridge Tramways
(See Tramways, Bridge)

Bridges
Toledo Bridge & Crane Co.

Buckets, Elevator
Caldwell & Son Co., H. W.
Jeffrey Manufacturing Co.
Link-Belt Co.
* Robins Conveying Belt Co.
Webster Mfg. Co.

Buckets, Grab
* Brown Hoisting Machinery Co.
* Clyde Iron Works
* Hunt Co., Inc., C. W.
Jeffrey Manufacturing Co.
* Link-Belt Co.
Orton & Steinbrenner Co.
* Robins Conveying Belt Co.

Buckets, Self-Dumping
Brown Hoisting Machinery Co.
* Clyde Iron Works
* Hunt Co., Inc., C. W.
Orton & Steinbrenner Co.

Bulldozers
* Wood & Co., R. D.

Burners, Gas
Weimer Machine Works Co.

Burners, Oil
Best, W. N.
Schutte & Koerting Co.

Cable, Wire
(See Rope, Wire)

Cable Railways
(See Railways, Cable)

Cableways, Wire
(See Tramways, Wire Rope)

Cables, Electrical
(See Wire and Cables, Electrical)

Calenders, Roll
Farrel Foundry & Machine Co.

Calorimeters
* American Steam Gauge & Valve Mfg. Co.

Cam Cutting Machines.
Garvin Machine Co.

Car Hauls, Cable and Chain
Fairmont Mining Mach. Co.
Jeffrey Mfg. Co.

Carriers and Elevators, Freight, Continuous
Jeffrey Manufacturing Co.
* Link-Belt Co.
Mathews Gravity Carrier Co.
* Robins Conveying Belt Co.
Webster Mfg. Co.

Cars, Cinder and Hot Metal
Weimer Machine Works Co.

Cars, Dump
* Hunt Co., Inc., C. W.
Weimer Machine Works Co.

Cars, Freight Elevator
Eastern Machinery Co.

Cars, Industrial Railway
* Hunt Co., Inc., C. W.
* Link-Belt Co.

Cars, Motor
* Hunt Co., Inc., C. W.

Castings, Aluminum
Aluminum Co. of America

Castings, Brass and Bronze
Crescent Mfg. Co.
* Homestead Valve Mfg. Co.

Castings, Die-Molded
Doehler Die-Casting Co.
Franklin Manufacturing Co.
* Veeder Mfg. Co.

Castings, Iron
* Brown Co., A. & F.
Builders Iron Foundry.
* Caldwell & Son Co., H. W.
* Falls Clutch & Machinery Co.
Fairmont Mining Mach. Co.
Harrisburg Foundry & Machine Works
Hill Clutch Co.
Holyoke Machine Co.
Homestead Valve Mfg. Co.
* Hooven, Owens, Rentschler Co.
* Lunkenheimer Co.
Mesta Machine Co.
* Robins Conveying Belt Co.
Royersford Foundry & Machine Co.
Weimer Machine Works Co.
* Wheeler Condenser & Engineering Co.
* Wood & Co., R. D.

Castings, Semi-Steel
Builders Iron Foundry
* Caldwell & Son Co., H. W.
Fairmont Mining Mach. Co.
* Hill Clutch Co.
* Hooven, Owens, Rentschler Co.
* Lunkenheimer Co.
* Wood & Co., R. D.

Castings, Steel
Mackintosh, Hemphill & Co.
Mesta Machine Co.

Celluloid and Linoleum Machinery
Farrel Foundry & Machine Co.

Cement, Belt
Schieren Co., Chas. A.

Cement, Fire Brick
* Betson Plastic Fire Brick Co.

Cement Machinery
* Hill Clutch Co.

Centrifugal Pumps
(See Pumps, Centrifugal)

Chain Drives
* Link-Belt Co.

Chain Grate Stokers
(See Stokers, Chain Grate)

Chains and Chain Links
Caldwell & Son Co., H. W.
Jeffrey Manufacturing Co.
* Link-Belt Co.
* Robins Conveying Belt Co.
Webster Mfg. Co.

Channeling Machines, Mine and Quarry
* Ingersoll-Rand Co.

Charging Machines, Furnace
* Alliance Machine Co.
Morgan Engineering Co.

Chimneys, Steel
(See Stacks, Steel)

Chucking Machines
Garvin Machine Co.
* Jones & Lamson Machine Co.
Le Blond Machine Tool Co., R. K.
* Warner & Swasey Co.

Chutes
Fairmont Mining Mach. Co.
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
* Link-Belt Co.

Chutes, Gravity Spiral
Mathews Gravity Carrier Co.

Circulators, Feed Water
Schutte & Koerting Co.

Circulators, Steam Heating
Schutte & Koerting Co.

Clamps, Pipe-Joint
Yarnall-Waring Co.

Clamps, Wire Rope
(See Wire Rope Fastenings)

Clutch Leathers
(See Leathers, Automobile)

Clutches, Friction
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
Dodge Mfg. Co.
Eastern Machinery Co.
* Falls Clutch & Machinery Co.
Farrel Foundry & Machine Co.
Hill Clutch Co.
Holyoke Machine Co.
Jeffrey Mfg. Co.
* Link-Belt Co.
* Moore & White Co.
Webster Mfg. Co.
Wood's Sons Co., T. B.

*Catalogue data of firms marked * appear in the A. S. M. E. Condensed Catalogues of Mechanical Equipment, 1914 Volume.*

Coal and Ash Handling Machinery
* Brown Hoisting Machinery Co.
* Caldwell & Son Co., H. W.
Fairmont Mining Mach. Co.
* Green Engineering Co.
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
* Link-Belt Co.
Orton & Steinbrenner Co.
* Robins Conveying Belt Co.
Webster Mfg. Co.

Coal Crushers
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
* Link-Belt Co.
Orton & Steinbrenner Co.
* Robins Conveying Belt Co.
Webster Mfg. Co.

Coal Mine Equipments and Supplies
Fairmont Mining Mach. Co.
Jeffrey Mfg. Co.

Coal Mining Machinery
* Ingersoll-Rand Co.
Jeffrey Mfg. Co.

Coaling Stations, Locomotive
* Brown Hoisting Machinery Co.
* Hunt Co., Inc., C. W.
* Link-Belt Co.
Webster Mfg. Co.

Cocks, Air and Gage
* American Steam Gauge & Valve Mfg. Co.
Ashton Valve Co.
* Jenkins Bros.
* Lunkenheimer Co.
* Pratt & Cady Co., Inc.
Walworth Mfg. Co.

Cocks, Blowoff
* Homestead Valve Mfg. Co.
* Lunkenheimer Co.
* Pratt & Cady Co., Inc.
Walworth Mfg. Co.

Cocks, Three-way and Four-way
* American Steam Gauge & Valve Mfg. Co.
* Homestead Valve Mfg. Co.
* Lunkenheimer Co.
* Pratt & Cady Co., Inc.
Walworth Mfg. Co.

Coils, Pipe
National Pipe Bending Co.
* Vilter Mfg. Co.

Coke Oven Machinery
* Alliance Machine Co.
* Brown Hoisting Machinery Co.

Cold Storage Insulation
* Keasbey Co., Robt. A.

Cold Storage Plants
* De La Vergne Machine Co.

Collars, Shafting
* Caldwell & Son Co., H. W.
Dodge Mfg. Co.
* Hill Clutch Co.
Royersford Foundry & Machine Co.
Wood's Sons Co., T. B.

Collectors, Dust
* Sturtevant Co., B. F.

Combustion Recorders
Simonds & Co., G. L.

Compressors, Air
* Devine Co., J. P.
* General Electric Co.
* Goulds Manufacturing Co.
* Hooven, Owens, Rentschler Co.
* Ingersoll-Rand Co.
MacIntosh, Hemphill & Co.
Mesta Machine Co.
* Nordberg Mfg. Co.
Roots Co., P. H. & F. M.

Compressors, Air, Compound
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.

Compressors, Ammonia
Vilter Mfg. Co.

Compressors, Gas
* Hooven, Owens, Rentschler Co.
* Ingersoll-Rand Co.
Mesta Machine Co.
* Nordberg Mfg. Co.
* Roots Co., P. H. & F. M.

Concrete Reinforcement
* Brown Hoisting Machinery Co.

Condensation Pumps with Automatic Receivers
(See Pumps, Condensation with Automatic Receivers)

Condensers
Davidson Co., M. T.
* Devine Co., J. P.
* Nordberg Mfg. Co.
* Wheeler Condenser & Engineering Co.

Condensers, Ammonia
De La Vergne Machine Co.
* Vilter Mfg. Co.

Condensers, Barometric
Mesta Machine Co.
* Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.

Condensers, Jet
Davidson Co., M. T.
General Condenser Co.
Schutte & Koerting Co.
* Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.

Condensers, Surface
Davidson Co., M. T.
General Condenser Co.
* Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.

Controllers, Automatic, for Temperature or for Pressure
(See Regulators)

Controllers, Electric
* General Electric Co.
Morgan Engineering Co.

Converters, Synchronous
* General Electric Co.

Conveying Machinery
Amdursen Co.
* Caldwell & Son Co., H. W.
Dodge Mfg. Co.
Fairmont Mining Mach. Co.
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
* Link-Belt Co.
Mathews Gravity Carrier Co.
* Robins Conveying Belt Co.
Webster Mfg. Co.

Conveying Systems, Pneumatic (Light Material)
Green Fuel Economizer Co.
Sturtevant Co., B. F.

Conveyors, Belt
Caldwell & Son Co., H. W.
Fairmont Mining Mach. Co.
Jeffrey Manufacturing Co.
Link-Belt Co.
Robins Conveying Belt Co.
Webster Mfg. Co.

Conveyors, Bucket, Pan or Apron
Caldwell & Son Co., H. W.
Fairmont Mining Mach. Co.
* Hunt Co., Inc., C. W.
Jeffrey Manufacturing Co.
Link-Belt Co.
Webster Mfg. Co.

Conveyors, Gravity
Mathews Gravity Carrier Co.

Conveyors, Gravity Roller
Mathews Gravity Carrier Co.

Conveyors, Screw
* Caldwell & Son Co., H. W.
Jeffrey Manufacturing Co.
Link-Belt Co.
Webster Mfg. Co.

Cooling Ponds, Spray
Schutte & Koerting Co.

Cooling Towers
* Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.

Copper, Drawn
* Roebling's Sons Co., John A.

Copper Wire and Cables
(See Wires and Cables, Electrical)

Copper Converting Machinery
* Alliance Machine Co.

Corliss Engines
(See Engines, Corliss)

Counters, Revolution
American Steam Gauge & Valve Mfg. Co.
Ashton Valve Co.
Bristol Co.
* Veeder Mfg. Co.

Countershafts
Builders Iron Foundry
Dodge Mfg. Co.
Hill Clutch Co.
Wood's Sons Co., T. B.

Counting Machines, Automatic
* Veeder Mfg. Co.

Couplings, Flexible
* Falls Clutch & Machinery Co.
* Hooven, Owens, Rentschler Co.
* Roots Co., P. H. & F. M.

Couplings, Pipe
* Lunkenheimer Co.
* Pratt & Cady Co., Inc.
Walworth Mfg. Co.

Couplings, Shaft
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
Cumberland Steel Co.
Dodge Mfg. Co.
* Falls Clutch & Machinery Co.
* Hill Clutch Co.
Holyoke Machine Co.
* Moore & White Co.
Royersford Foundry & Machine Co.
Webster Mfg. Co.
Wood's Sons Co., T. B.

Couplings, Union
(See Unions)

Couplings, Universal Joint
Wood's Sons Co., T. B.

Covering, Boiler
Keasbey Co., Robt. A.

Covering, Pipe and Tank
Keasbey Co., Robt. A.

Covering, Steam Pipe
Keasbey Co., Robt. A.

Cranes, Electric Travelling
* Alliance Machine Co.
Box & Co., Alfred
Brown Hoisting Machinery Co.
Manning, Maxwell & Moore, Inc.
Morgan Engineering Co.
Shaw Electric Crane Co.
Toledo Bridge & Crane Co.

Cranes, Gantry
* Alliance Machine Co.
* Brown Hoisting Machinery Co.
Link-Belt Co.
Manning, Maxwell & Moore, Inc.
Morgan Engineering Co.
Orton & Steinbrenner Co.
Shaw Electric Crane Co.
Toledo Bridge & Crane Co.

Cranes, Hand Power
Box & Co., Alfred
Brown Hoisting Machinery Co.
* Clyde Iron Works
Toledo Bridge & Crane Co.

Cranes, Hydraulic
* Alliance Machine Co.
* Wood & Co., R. D.

Cranes, Jib
* Alliance Machine Co.
Box & Co., Alfred
Brown Hoisting Machinery Co.
Morgan Engineering Co.
Toledo Bridge & Crane Co.
* Wood & Co., R. D.

Cranes, Locomotive
Brown Hoisting Machinery Co.
Link-Belt Co.
Morgan Engineering Co.
Orton & Steinbrenner Co.

Cranes, Pillar
Brown Hoisting Machinery Co.
Orton & Steinbrenner Co.
Toledo Bridge & Crane Co.

Cranes, Portable
Brown Hoisting Machinery Co.
* Clyde Iron Works
Lidgerwood Mfg. Co.

Cranes, Wharf
Shaw Electric Crane Co.

Crushers, Jaw
Farrel Foundry & Machine Co.

Crushers, Roll
Eastern Machinery Co.
Jeffrey Manufacturing Co.
Orton & Steinbrenner Co.

Crushing and Grinding Machinery
Farrel Foundry & Machine Co.
* Fulton Iron Works.
Jeffrey Mfg. Co.

Cutters, Bolt
Wells Bros. Co.

Damper Regulators
(See Regulators, Damper)

Derricks and Derrick Fittings
* Brown Hoisting Machinery Co.
* Clyde Iron Works
Lidgerwood Mfg. Co.

Destructors, Refuse
Power Specialty Co.

Die Castings
(See Castings, Die)

Dies, Screw and Thread Cutting
* Jones & Lamson Machine Co.
Wells Bros. Co.

Dies, Self-opening
* Jones & Lamson Machine Co.
Wells Bros. Co.

Digesters, Pulp
* Hooven, Owens, Rentschler Co.

Discs, Steel
* Auburn Ball Bearing Co.

Discs, Valve
(See Valve Discs)

Distillers
Davidson Co., M. T.

Drainage Systems
* Morehead Mfg. Co.

Draft, Mechanical
(See Mechanical Draft Apparatus)

Dredges, Hydraulic
* Morris Machine Works

Drilling Machines, Electric
Fortuna Machine Co.

Drilling Machines, Hand
Fortuna Machine Co.

Drilling Machines, Multiple Spindle
Garvin Machine Co.

Drilling Machines, Pneumatic
* Ingersoll-Rand Co.

Drilling Machines, Portable
Fortuna Machine Co.

Drilling Machines, Rock
* Ingersoll-Rand Co.

Drilling Machines, Vertical
Garvin Machine Co.

Drills, Coal and Slate
Jeffrey Mfg. Co.

Drop Forgings, Hammers, Presses, etc.
(See Forgings, Hammers, Presses, etc., Drop)

Dryers, Direct Heat
Ruggles-Coles Engineering Co.

Dryers, Rotary
* Devine Co., J. P.
Ruggles-Coles Engineering Co.

Dryers, Vacuum
* Devine Co., J. P.

Drying Apparatus
* Devine Co., J. P.
Green Fuel Economizer Co.
Ruggles-Coles Engineering Co.
Sturtevant Co., B. F.

Economizers, Fuel
Green Fuel Economizer Co.
* Sturtevant Co., B. F.

Ejectors
* Lunkenheimer Co.
Manning, Maxwell & Moore, Inc.
Schutte & Koerting Co.

Ejectors, Ash, Hydraulic
Davidson Co., M. T.

Ejectors, Ash, Pneumatic
* Green Engineering Co.

Electric Generators, Hoists, Trucks, Welding, etc.
(See Generators, Hoists, Trucks, Welding, etc., Electric)

Electrical Instruments
Bristol Co.
Brown Instrument Co.
* General Electric Co.
Wagner Electric Mfg. Co.
Weston Electrical Instrument Co.

Electrical Machinery
* General Electric Co.
Wagner Electric Mfg. Co.

Elevating and Conveying Machinery
Caldwell & Son Co., H. W.
Dodge Mfg. Co.
Fairmont Mining Mach. Co.
* Hill Clutch Co.
* Hunt Co., Inc., C. W.
Jeffrey Manufacturing Co.
* Link-Belt Co.
Mathews Gravity Carrier Co.
* Robins Conveying Belt Co.
Webster Mfg. Co.

*Catalogue data of firms marked * appear in the A. S. M. E. Condensed Catalogues of Mechanical Equipment, 1914 Volume.*

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Grinding Machines, Tool
Heald Machine Co.
Le Blond Machine Tool Co., R. K.

Gun and Motor Carriages
Morgan Engineering Co.

Hammers, Drop
* Alliance Machine Co.

Hammers, Pneumatic
* Ingersoll-Rand Co.

Hammers, Steam
* Alliance Machine Co.
Morgan Engineering Co.

Hangers, Shaft
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
Dodge Mfg. Co.
* Falls Clutch & Machinery Co.
* Hill Clutch Co.
Jeffrey Mfg. Co.
Royersford Foundry & Machine Co.
Webster Mfg. Co.
Wood's Sons Co., T. B.

Head Gates
Holyoke Machine Co.

Heaters, Feed Water (Closed)
Erie City Iron Works
National Pipe Bending Co.
Schutte & Koerting Co.
* Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.

Heaters, Metering
Harrison Safety Boiler Works

Heaters and Purifiers, Feed Water (Open)
Erie City Iron Works
Harrison Safety Boiler Works
National Pipe Bending Co.

Heating Boilers
(See Boilers, Heating)

Heating and Ventilating Apparatus
Green Fuel Economizer Co.
* Smith Co., H. B.
* Sturtevant Co., B. F.

Hoisting and Conveying Machinery
Box & Co., Alfred
* Brown Hoisting Machinery Co.
* Clyde Iron Works
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
Lidgerwood Mfg. Co.
* Link-Belt Co.
Orton & Steinbrenner Co.
Robins Conveying Belt Co.

Hoists, Air
* Ingersoll-Rand Co.
* Nordberg Mfg. Co.

Hoists, Belt
Clyde Iron Works
Lidgerwood Mfg. Co.

Hoists, Electric
* Alliance Machine Co.
Box & Co., Alfred
Brown Hoisting Machinery Co.
* Clyde Iron Works
* General Electric Co.
* Hunt Co., Inc., C. W.
Lidgerwood Mfg. Co.
* Link-Belt Co.
* Nordberg Mfg. Co.
Orton & Steinbrenner Co.
* Robins Conveying Belt Co.
Shaw Electric Crane Co.

Hoists, Friction
Eastern Machinery Co.

Hoists, Hand
* Brown Hoisting Machinery Co.
* Clyde Iron Works
Link-Belt Co.

Hoists, Mine
Lidgerwood Mfg. Co.
* Nordberg Mfg. Co.

Hoists, Skip
* Hunt Co., Inc., C. W.
* Robins Conveying Belt Co.

Hoists, Steam
* Clyde Iron Works
* Hunt Co., Inc., C. W.
Lidgerwood Mfg. Co.
* Morris Machine Works
* Nordberg Mfg. Co.
Orton & Steinbrenner Co.

Holders, Gas
* Wood & Co., R. D.

Hose, Air
* Goodrich Co., B. F.
* Ingersoll-Rand Co.
Manhattan Rubber Mfg. Co.

Hose, Linen
* Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.

Hose, Oil
* Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.

Hose, Rubber
* Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.

Hose, Steam
* Goodrich Co., B. F.
* Ingersoll-Rand Co.
Manhattan Rubber Mfg. Co.

Hose, Suction
* Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.

Hose Attachments (Couplings, Bands, Holders, Clamps, etc.)
* Goodrich Co., B. F.
* Ingersoll-Rand Co.
Manhattan Rubber Mfg. Co.

Hydrants, Fire
Chapman Valve Mfg. Co.
* Ludlow Valve Mfg. Co.
* Pratt & Cady Co., Inc.
* Wood & Co., R. D.

Hydraulic Jacks, Rams, Presses, Turbines, etc.
(See Jacks, Rams, Presses, Turbines, etc., Hydraulic)

Hydraulic Machinery
* Alliance Machine Co.
Holyoke Machine Co.
Mackintosh, Hemphill & Co.
Morgan Engineering Co.
* Wood & Co., R. D.

Hydrokineters
Schutte & Koerting Co.

Hydrometers
* Tagliabue Mfg. Co., C. J.

Hygrometers
Brown Instrument Co.
* Tagliabue Mfg. Co., C. J.

Ice and Refrigeration Machinery
* De La Vergne Machine Co.
* Vilter Mfg. Co.

Ice Tools
* Caldwell & Son Co., H. W.

Impregnating Apparatus
* Devine Co., J. P.

Incandescent Lamps
(See Lamps, Incandescent)

Indicator Posts
Chapman Valve Mfg. Co.
* Ludlow Valve Mfg. Co.
* Pratt & Cady Co., Inc.
* Wood & Co., R. D.

Indicators, Engine
* American Steam Gauge & Valve Mfg. Co.
Manning, Maxwell & Moore, Inc.

Indicators, Sight Flow
* Richardson-Phenix Co.

Indicators, Smoke
Simonds & Co., G. L.

Indicators, Speed
* American Steam Gauge & Valve Mfg. Co.
Brown Instrument Co.
* Veeder Manufacturing Co.
Weston Electrical Instrument Co.

Industrial Railway Equipment
* Hunt Co., Inc., C. W.

Ingot Strippers
* Alliance Machine Co.
Morgan Engineering Co.

Injectors
Manning, Maxwell & Moore, Inc.
* Lunkenheimer Co.
Schutte & Koerting Co.

Insulating Materials (Heat and Cold)
* Keasbey Co., Robt. A.

Jigs and Fixtures
Cowdrey Machine Works, C. H.

Joints, Expansion
* Lunkenheimer Co.
Power Specialty Co.
Walworth Mfg. Co.
Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.

Joints, Flanged Pipe
Walworth Mfg. Co.

Joints, Rail
Rail Joint Co.

Jolt Ramming Machines
(See Rammers, Foundry)

Kilns, Dry
* Sturtevant Co., B. F.

Lamps, Incandescent and Arc
* General Electric Co.

Land-Clearing Machinery
* Clyde Iron Works

Lathe Attachments
Le Blond Machine Tool Co., R. K.

Lathes
Builders Iron Foundry
Garvin Machine Co.
* Jones & Lamson Machine Co.
Le Blond Machine Tool Co., R. K.
Manning, Maxwell & Moore, Inc.
* Warner & Swasey Co.

Lathes, Automatic
* Jones & Lamson Machine Co.

Lathes, Brass
Garvin Machine Co.
* Warner & Swasey Co.

Lathes, Chucking
* Jones & Lamson Machine Co.

Lathes, Speed
Le Blond Machine Tool Co., R. K.

Lathes, Turret
Garvin Machine Co.
* Jones & Lamson Machine Co.
* Warner & Swasey Co.

Lathes, Turret, Vertical
King Machine Tool Co.

Leather Belting, Packing, etc.
(See Belting, Packing, etc., Leather)

Leathers, Automobile
Schieren Co., Chas. A.

Leathers, Pump
Schieren Co., Chas. A.
Williams & Sons, I. B.

Lightning Arresters
* General Electric Co.

Linings, Furnace
Best, W. N.
* Betson Plastic Fire Brick Co.

Liquid Fuel Equipment
Best, W. N.

Loaders, Box Car
Fairmont Mining Mach. Co.

Loaders, Wagon
Jeffrey Mfg. Co.
* Link-Belt Co.

Locomotives, Compressed Air
* Ingersoll-Rand Co.

Locomotives, Electric
* General Electric Co.
* Hunt Co., Inc., C. W.
Jeffrey Mfg. Co.
* Robins Conveying Belt Co.

Logging Machinery
* Clyde Iron Works
Lidgerwood Mfg. Co.

Lubricants
Royersford Foundry & Machine Co.
* Texas Co.

Lubricators, Cylinder
Crescent Mfg. Co.
* Lunkenheimer Co.
* Richardson-Phenix Co.

Lubricators, Force-Feed
* Lunkenheimer Co.
* Pickering Governor Co.
* Richardson-Phenix Co.

Lubricators, Hydrostatic
Crescent Mfg. Co.
* Lunkenheimer Co.

Machinery
(Is classified under the headings descriptive of character thereof)

Machinery Dealers
Garvin Machine Co.
Manning, Maxwell & Moore, Inc.

Machinists and Engineers
* Brown Co., A. & F.
Builders Iron Foundry
* Caldwell & Son Co., H. W.
Cowdrey Machine Works, C. H.
* Hill Clutch Co.
Lammert & Mann
Webster Mfg. Co.
Weimer Machine Works Co.
* Wood & Co., R. D.

Marine Transfers
Lidgerwood Mfg. Co.

Mechanical Draft Apparatus
Green Fuel Economizer Co.
* Sturtevant Co., B. F.

Mechanical Stokers
(See Stokers)

Metals, Bearing
Dodge Mfg. Co.

Metals, Extruded
* Aluminum Co. of America

Metal Work, Plate
Heine Safety Boiler Co.
* Keeler Co., E.
* Wood & Co., R. D.

Meters, Air, Steam and Gas
Builders Iron Foundry
* General Electric Co.

Meters, Electric
Bristol Co.
Brown Instrument Co.
* General Electric Co.

Meters, V-Notch
Harrison Safety Boiler Works
Yarnall-Waring Co.

Meters, Venturi
Builders Iron Foundry
* National Meter Co.

Meters, Water
Builders Iron Foundry
* General Electric Co.
Harrison Safety Boiler Works
* National Meter Co.
Yarnall-Waring Co.

Micrometers
Wells Bros. Co.

Milling Attachments
Garvin Machine Co.
Le Blond Machine Tool Co., R. K.

Milling Machines, Hand
Garvin Machine Co.

Milling Machines, Horizontal
Garvin Machine Co.

Milling Machines, Plain
Garvin Machine Co.
Le Blond Machine Tool Co., R. K.
* Warner & Swasey Co.

Milling Machines, Universal
Garvin Machine Co.
Le Blond Machine Tool Co., R. K.

Milling Machines, Vertical
Garvin Machine Co.

Mills, Blooming and Slabbing
Mackintosh, Hemphill & Co.
Mesta Machine Co.

Mills, Sheet and Plate
Mackintosh, Hemphill & Co.
Mesta Machine Co.

Mills, Structural, Rail and Bar
Mackintosh, Hemphill & Co.
Mesta Machine Co.

Mills, Sugar Cane
Farrel Foundry & Machine Co.
* Fulton Iron Works
Mesta Machine Co.

Monorail Systems
(See Tramrail Systems, Overhead)

Motor-Generators
* General Electric Co.
Wagner Electric Mfg. Co.

Motors, Compressed Air
* Ingersoll-Rand Co.

Motors, Electric
* General Electric Co.
* Sturtevant Co., B. F.
Wagner Electric Mfg. Co.

Nozzles, Blast
Schutte & Koerting Co.

Nozzles, Sand and Air
* Ingersoll-Rand Co.
* Lunkenheimer Co.

Nozzles, Spray
Schutte & Koerting Co.

*Catalogue data of firms marked * appear in the A. S. M. E. Condensed Catalogues of Mechanical Equipment, 1914 Volume.*

Recording Instruments
American Steam Gauge & Valve Mfg. Co.
Ashton Valve Co.
Bristol Co.
Brown Instrument Co.
Builders Iron Foundry
* General Electric Co.
Harrison Safety Boiler Work
Industrial Instrument Co.
Yarnall Waring Co.

Rectifiers
Wagner Electric Mfg. Co.

Refrigerating Machinery
* De La Vergne Machine Co.
* Vilter Mfg. Co.

Refuse Destructors
(See Destructor, Refuse)

Regulators, Blower
Davis Regulator Co., G. M.
Hughson Steam Specialty Co.
* Tagliabue Mfg. Co., C. J.

Regulators, Damper
Davis Regulator Co., G. M.

Regulators, Electric
* General Electric Co.

Regulators, Feed Water
* Almy Water Tube Boiler Co.

Regulators, Flow (Steam)
Davis Regulator Co., G. M.
Schutte & Koerting Co.

Regulators, Pressure
Davis Regulator Co., G. M.
Hughson Steam Specialty Co.
* Tagliabue Mfg. Co., C. J.

Regulators, Pump
(See Governors, Pump)

Regulators, Temperature
* Tagliabue Mfg. Co., C. J.

Retarders, Mine and Railroad Car
Fairmont Mining Mach. Co.

Revolution Counters
(See Counters, Revolution)

Riveters, Hydraulic
* Alliance Machine Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Engineering Co.
* Wood & Co., R. D.

Riveters, Pneumatic
* Ingersoll-Rand Co.

Rivets
* Aluminum Co. of America

Roller Bearings
(See Bearings, Roller)

Rolling Mill Machinery
* Alliance Machine Co.
Farrel Foundry & Machine Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Engineering Co.

Rolls, Crushing
Farrel Foundry & Machine Co.

Rolls, Forging
Mesta Machine Co.

Rolls, Sand, Chilled and Steel
Farrel Foundry & Machine Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.

Rolls, Rubber
* Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.

Roofing
* Texas Co.

Rope Drives
* Brown Co., A. & F.
Caldwell & Son Co., H. W.
Dodge Mfg. Co.
* Falls Clutch & Machinery Co.
Hill Clutch Co.
Jeffrey Mfg. Co.
Webster Mfg. Co.
Wood's Sons Co., T. B.

Rope, Hoisting
* Clyde Iron Works
* Hunt Co., Inc., C. W.
Roebling's Sons Co., John A.

Rope, Transmission
Caldwell & Son Co., H. W.
* Hunt Co., Inc., C. W.
Roebling's Sons Co., John A.

Rope, Wire
* Clyde Iron Works
Lidgerwood Mfg. Co.
Roebling's Sons Co., John A.

Rubber Goods, Mechanical
* Goodrich Co., B. F.
* Jenkins Bros.
Manhattan Rubber Mfg. Co.

Rubber Mill Machinery
Farrel Foundry & Machine Co.

Sand Blast Apparatus
* De La Vergne Machine Co.
* Ingersoll-Rand Co.
Lunkenheimer Co.

Screens, Revolving
Caldwell & Son Co., H. W.
Fairmont Mining Mach. Co.
Farrel Foundry & Machine Co.
Jeffrey Manufacturing Co.
* Link-Belt Co.
Robins Conveying Belt Co.
Webster Mfg. Co.

Screens, Shaking
* Caldwell & Son Co., H. W.
Fairmont Mining Mach. Co.
Jeffrey Manufacturing Co.
* Link-Belt Co.
* Robins Conveying Belt Co.

Screw Cutting Dies
(See Dies, Screw and Thread Cutting)

Screw Machines, Hand
Garvin Machine Co.
* Jones & Lamson Mach. Co.
* Warner & Swasey Co.

Screw Plates
Wells Bros. Co.

Screw Steel
Union Drawn Steel Co.

Screws, Safety Set
Bristol Co.

Separators, Air
General Condenser Co.

Separators, Ammonia
* De La Vergne Machine Co.

Separators, Oil
* De La Vergne Machine Co.
General Condenser Co.
Harrison Safety Boiler Works
Hughson Steam Specialty Co.
National Pipe Bending Co.
* Wheeler Condenser & Engineering Co.

Separators, Steam
General Condenser Co.
Harrison Safety Boiler Works
Hughson Steam Specialty Co.
National Pipe Bending Co.

Shafting
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
Cumberland Steel Co.
Dodge Mfg. Co.
Falls Clutch & Machinery Co.
* Hill Clutch Co.
Holyoke Machine Co.
* Union Drawn Steel Co.
Wood's Sons Co., T. B.

Shapes, Cold Drawn Steel
* Union Drawn Steel Co.

Shears, Alligator
Farrel Foundry & Machine Co.
Mesta Machine Co.
Morgan Engineering Co.

Shears, Hydraulic
* Alliance Machine Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Engineering Co.
* Wood & Co., R. D.

Shears, Plate
* Alliance Machine Co.
Farrel Foundry & Machine Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Engineering Co.
* Wood & Co., R. D.

Sheaves, Rope
* Brown Co., A. & F.
* Caldwell & Son Co., H. W.
* Clyde Iron Works
Dodge Mfg. Co.
Fairmont Mining Mach. Co.
* Falls Clutch & Machinery Co.
* Hill Clutch Co.
Jeffrey Mfg. Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Webster Mfg. Co.
Wood's Sons Co., T. B.

Sheet Mill Machinery
Mesta Machine Co.

Shipbuilding Machinery
Morgan Engineering Co.

Shredders
Jeffrey Mfg. Co.

Sirens
(See Whistles, Steam)

Skiving Machines
Fortuna Machine Co.

Slide Valves
(See Valves, Slide)

Sluice Gates
(See Gates, Sluice)

Smoke Indicators
(See Indicators, Smoke)

Smoke Stacks and Flues
(See Stacks, Steel)

Softeners and Purifiers, Water
Dodge Mfg. Co.
Harrison Safety Boiler Wks.
Scaife & Sons Co., Wm. B.

Special Machinery
* Brown Co., A. & F.
Builders Iron Foundry
Cowdrey Machine Works, C. H.
Farrel Foundry & Machine Co.
Garvin Machine Co.
Holyoke Machine Co.
Mackintosh, Hemphill & Co.
Mesta Machine Co.
Morgan Engineering Co.
* Morris Co., I. P.
Providence Engineering Works
* Ruggles-Coles Engineering Co.
* Vilter Mfg. Co.
* Wood & Co., R. D.

Speed Transmissions, Variable
* Moore & White Co.

Speed Reducing Transmissions
James Mfg. Co., D. O.

Spirals, Gravity Roller
Mathews Gravity Carrier Co.

Spouts, Grain
* Caldwell & Son Co., H. W.
Webster Mfg. Co.

Spray Nozzles
(See Nozzles, Spray)

Sprockets
* Caldwell & Son Co., H. W.
* Hill Clutch Co.
Link-Belt Co.
Robins Conveying Belt Co.
Webster Mfg. Co.

Sockets, Wire Rope
(See Wire Rope Fastenings)

Soot Blowing Systems
Simonds & Co., G. L.

Stacks, Steel
Heine Safety Boiler Co.
* Keeler Co., E.

Stamps, Steam
* Nordberg Manufacturing Co.

Starters, Self (Automobile)
Wagner Electric Mfg. Co.

Steam Engines, Separators, Shovels, Superheaters, Traps, Turbines, etc.
(See Engines, Separators, Shovels, Superheaters, Traps, Turbines, etc., Steam)

Steam Specialties
* American Steam Gauge & Valve Mfg. Co.
Davis Regulator Co., G. M.
Hughson Steam Specialty Co.
* Lunkenheimer Co.
Manning, Maxwell & Moore, Inc.
* Morehead Mfg. Co.

Steel, Bright Finished
* Union Drawn Steel Co.

Steel, Cold Drawn
* Union Drawn Steel Co.

Steel, Cold Rolled
Cumberland Steel Co.
* Union Drawn Steel Co.

Steel, Nickel
* Union Drawn Steel Co.

Steel, Open Hearth
* Union Drawn Steel Co.

Steel, Vanadium
* Union Drawn Steel Co.

Sterilizers, Water, Electric
Electric Water Sterilizer Co.

Steel Plate Construction
Heine Safety Boiler Co.
* Keeler Co., E.
* Wood & Co., R. D.

Stocks and Dies
Wells Bros. Co.

Stokers
American Engineering Co.
Babcock & Wilcox Co.
* Green Engineering Co.
* Murphy Iron Works

Stokers, Chain Grate
Babcock & Wilcox Co.
Green Engineering Co.

Stokers, Inclined Grate
* Murphy Iron Works

Stokers, Underfeed
American Engineering Co.

Strainers, Water
Davidson Co., M. T.
Schutte & Koerting Co.

Structural Steel Work
Toledo Bridge & Crane Co.

Sugar Machinery
Farrel Foundry & Machine Co.
* Hooven, Owens, Rentschler Co.
* Wood & Co., R. D.

Superheaters, Air
Power Specialty Co.

Superheaters, Steam
Babcock & Wilcox Co.
Heine Safety Boiler Co.
Power Specialty Co.

Switchboards
* General Electric Co.

Switches, Electric
* General Electric Co.

Switches and Frogs, Railroad
Rail Joint Co.

Synchronous Converters
(See Converters, Synchronous)

Syphons (Steam-Jet)
Schutte & Koerting Co.

Tachometers
Brown Instrument Co.
Industrial Instrument Co.
* Veeder Mfg. Co.
Weston Electrical Instrument Co.

Tackle Blocks
(See Blocks, Tackle)

Tank Work (Air, Gas, Oil and Water)
Heine Safety Boiler Co.
* Keeler Co., E.
Scaife & Sons Co., Wm. B.
* Wood & Co., R. D.

Tanks, Aluminum
* Aluminum Co. of America

Tanks, Copper
Scaife & Sons Co., Wm. B.

Tanks, Storage
Scaife & Sons Co., Wm. B.

Tanks, Welded
Scaife & Sons Co., Wm. B.

Tapping Machines
Garvin Machine Co.

Taps and Dies
Wells Bros. Co.

Telphers
(See Tramrail Systems, Overhead)

Ties, Steel
Fairmont Mining Mach. Co.

Thermometers
* American Steam Gauge & Valve Mfg. Co.
Ashton Valve Co.
Bristol Co.
Brown Instrument Co.
Industrial Instrument Co.
* Tagliabue Mfg. Co., C. J.

Thread Cutting Tools
* Jones & Lamson Machine Co.
Wells Bros. Co.

Time Controllers
* Tagliabue Mfg. Co., C. J.

Time Recorders
Bristol Co.
* Brown Instrument Co.
Industrial Instrument Co.

Tipples, Steel
Fairmont Mining Mach. Co.
Jeffrey Mfg. Co.
Link-Belt Co.
Webster Mfg. Co.

Tools, Brass-Working Machine
* Warner & Swasey Co.

Tools, Pipe Fitters
Walworth Mfg. Co.

Torches, Hand
Best, W. N.

Track, Industrial
* Hunt Co., Inc., C. W.

Tramrail Systems, Overhead
Box & Co., Alfred
Brown Hoisting Machinery Co.
Link-Belt Co.
Manning, Maxwell & Moore, Inc.
Shaw Electric Crane Co.

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One of the largest collections of engineering literature in the world is the Engineering Library in the Engineering Societies Building, 29 West 39th Street, New York.

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The library is open from 9 a.m. to 9 p.m, with trained librarians in constant attendance. Its resources are at the service of the engineering and scientific public.

Tramways, Bridge
* Brown Hoisting Machinery Co.
* Hunt Co., Inc., C. W.
* Link-Belt Co.
* Robins Conveying Belt Co.
Toledo Bridge & Crane Co.

Tramways, Loop-Line
[illegible]

Tramways, Wire Rope
[illegible]
* Clyde Iron Works
Lidgerwood Mfg. Co.
* Roebling's Sons Co., John A.

Transfer Tables
[illegible]

Transformers, Electric
* General Electric Co.
Wagner Electric Mfg. Co.

Transmission Machinery
(See Power Transmission Machinery)

Traps, Condenser
* Morehead Mfg. Co.

Traps, Return
Hughson Steam Specialty Co.
General Condenser Co.
* Morehead Mfg. Co.
* Pratt & Cady Co., Inc.

Traps, Steam
* American Steam Gauge & Valve Mfg. Co.
Davis Regulator Co., G. M.
General Condenser Co.
Hughson Steam Specialty Co.
* Jenkins Bros.
* Morehead Mfg. Co.
* Pratt & Cady Co., Inc.
Schutte & Koerting Co.
* Sturtevant Co., B. F.

Traps, Vacuum
Hughson Steam Specialty Co.
General Condenser Co.
* Morehead Mfg. Co.

Trucks, Electric
* Hunt Co., Inc., C. W.

Tube Cleaners, Boiler
Simonds & Co., G. L.

Tubes, Condenser
* Aluminum Co. of America

Tubing, Aluminum
* Aluminum Co. of America

Tubing, Rubber
* Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.

Tumbling Barrels
(See Barrels, Tumbling)

Turbines, Hydraulic
Holyoke Machine Co.
* Morris Co., I. P.

Turbines, Steam
* General Electric Co.
* Sturtevant Co., B. F.

Turbo-Generators
* General Electric Co.
* Sturtevant Co., B. F.

Turntables
* Hunt Co., Inc., C. W.

Turret Machines
Garvin Machine Co.
* Jones & Lamson Machine Co.
Le Blond Machine Tool Co., R. K.
* Warner & Swasey Co.

Turret Machines, Vertical
King Machine Tool Co.

Unions
* Lunkenheimer Co.
Walworth Mfg. Co.

Uniflow Engines
(See Engines, Uniflow)

Underfeed Stokers
(See Stokers, Underfeed)

Unloaders, Air Compressor
Yarnall-Waring Co.

Unloaders, Ballast
Lidgerwood Mfg. Co.

Vacuum Dryers, Pans, Pumps, Traps, etc.
(See Pans, Pumps, Traps, etc., Vacuum)

Valve Balls
* Auburn Ball Bearing Co.
* Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.

Valve Boxes
Chapman Valve Mfg. Co.
* Ludlow Valve Mfg. Co.
* Pratt & Cady Co., Inc.
* Wood & Co., R. D.

Valve Discs
* Goodrich Co., B. F.
* Jenkins Bros.
Manhattan Rubber Mfg. Co.

Valves, Air, Automatic
Davis Regulator Co., G. M.
* Jenkins Bros.
* Smith Co., H. B.

Valves, Air Relief
* Ludlow Valve Mfg. Co.
* Lunkenheimer Co.
Schutte & Koerting Co.

Valves, Ammonia
Chapman Valve Mfg. Co.
* De La Vergne Machine Co.
* Jenkins Bros.
* Ludlow Valve Mfg. Co.
* Lunkenheimer Co.
* Pratt & Cady Co., Inc.
* Vilter Mfg. Co.
Walworth Mfg. Co.

Valves, Angle Gate
Chapman Valve Mfg. Co.
Ludlow Valve Mfg. Co.
* Lunkenheimer Co.
Nelson Valve Co.
* Pratt & Cady Co., Inc.
* Wood & Co., R. D.

Valves, Back Pressure
Davis Regulator Co., G. M.
Harrison Safety Boiler Works
Hughson Steam Specialty Co.
* Jenkins Bros.
* Lunkenheimer Co.
Nelson Valve Co.
* Pratt & Cady Co., Inc.
Schutte & Koerting Co.
Walworth Mfg. Co.

Valves, Balanced
Davidson Co., M. T.
Davis Regulator Co., G. M.
* Homestead Valve Mfg. Co.
Hughson Steam Specialty Co.
* Ludlow Valve Mfg. Co.
* Lunkenheimer Co.
Schutte & Koerting Co.
Walworth Mfg. Co.

Valves, Balanced Distribution
* American Balance Valve Co.

Valves, Blowoff
Ashton Valve Co.
Chapman Valve Mfg. Co.
* Homestead Valve Mfg. Co.
Hughson Steam Specialty Co.
* Jenkins Bros.
* Ludlow Valve Mfg. Co.
* Lunkenheimer Co.
* Pratt & Cady Co., Inc.
Walworth Mfg. Co.
Yarnall-Waring Co.

Valves, Butterfly
Chapman Valve Mfg. Co.
* Lunkenheimer Co.
Schutte & Koerting Co.

Valves, By-Pass
Chapman Valve Mfg. Co.
* Jenkins Bros.
* Ludlow Valve Mfg. Co.
* Lunkenheimer Co.
Nelson Valve Co.
* Pratt & Cady Co., Inc.

Valves, Check
Chapman Valve Mfg. Co.
* Jenkins Bros.
* Ludlow Valve Mfg. Co.
* Lunkenheimer Co.
Nelson Valve Co.
Pratt & Cady Co., Inc.
Schutte & Koerting Co.
Walworth Mfg. Co.
* Wood & Co., R. D.

Valves, Exhaust Relief
Davidson Co., M. T.
Davis Regulator Co., G. M.
Harrison Safety Boiler Works
Hughson Steam Specialty Co.
* Jenkins Bros.
* Pratt & Cady Co., Inc.
Schutte & Koerting Co.
Walworth Mfg. Co.
* Wheeler Condenser & Engineering Co.
* Wheeler Mfg. Co., C. H.

Valves, Float
Davis Regulator Co., G. M.
* Homestead Valve Mfg. Co.
Hughson Steam Specialty Co.
* Ludlow Valve Mfg. Co.
Schutte & Koerting Co.

Valves, Foot
* Ludlow Valve Mfg. Co.
Walworth Mfg. Co.
* Wood & Co., R. D.

Valves, Gate
Chapman Valve Mfg. Co.
* Jenkins Bros.
Ludlow Valve Mfg. Co.
* Lunkenheimer Co.
Nelson Valve Co.
* Pratt & Cady Co., Inc.
Schutte & Koerting Co.
Walworth Mfg. Co.
* Wood & Co., R. D.

Valves, Globe, Angle and Cross
* Jenkins Bros.
* Lunkenheimer Co.
Manning, Maxwell & Moore, Inc.
Nelson Valve Co.
* Pratt & Cady Co., Inc.
Walworth Mfg. Co.

Valves, Hose
Chapman Valve Mfg. Co.
* Jenkins Bros.
* Ludlow Valve Mfg. Co.
* Lunkenheimer Co.
Nelson Valve Co.
Pratt & Cady Co., Inc.
Walworth Mfg. Co.

Valves, Hydraulic
Chapman Valve Mfg. Co.
Davidson Co., M. T.
* Lunkenheimer Co.
Morgan Engineering Co.
Nelson Valve Co.
* Pratt & Cady Co., Inc.
Schutte & Koerting Co.
Walworth Mfg. Co.
* Wood & Co., R. D.
Yarnall-Waring Co.

Valves, Hydraulic Operating
* Lunkenheimer Co.
Schutte & Koerting Co.
* Wood & Co., R. D.

Valves, Non-Return
Davis Regulator Co., G. M.
Hughson Steam Specialty Co.
* Jenkins Bros.
* Lunkenheimer Co.
Nelson Valve Co.
* Pratt & Cady Co., Inc.
Schutte & Koerting Co.
Walworth Mfg. Co.

Valves, Piston
* American Balance Valve Co.

Valves, Plug
* Homestead Valve Mfg. Co.

Valves, Pop Safety
* American Steam Gauge & Valve Mfg. Co.
Ashton Valve Co.
* Lunkenheimer Co.
Manning, Maxwell & Moore, Inc.

Valves, Pump
* Goodrich Co., B. F.
* Goulds Manufacturing Co.
* Jenkins Bros.
Manhattan Rubber Mfg. Co.

Valves, Radiator
* Jenkins Bros.
* Lunkenheimer Co.
Walworth Mfg. Co.

Valves, Reducing
Davis Regulator Co., G. M.
Hughson Steam Specialty Co.

Valves, Regulating
Davis Regulator Co., G. M.
Hughson Steam Specialty Co.
* Lunkenheimer Co.

Valves, Relief (Water)
* American Steam Gauge & Valve Mfg. Co.
Ashton Valve Co.
Ludlow Valve Mfg. Co.
* Lunkenheimer Co.
* Wood & Co., R. D.

Valves, Safety
American Steam Gauge & Valve Mfg. Co.
* Jenkins Bros.
* Lunkenheimer Co.
Walworth Mfg. Co.

Valves, Slide
* American Balance Valve Co.

Valves, Steel (Superheated Steam)
Chapman Valve Mfg. Co.
* Jenkins Bros.
* Ludlow Valve Mfg. Co.
* Lunkenheimer Co.
Nelson Valve Co.
Pratt & Cady Co., Inc.
Schutte & Koerting Co.
Walworth Mfg. Co.

Valves, Stop and Check
(See Valves, Non-Return)

Valves, Throttle
* Jenkins Bros.
* Ludlow Valve Mfg. Co.
* Lunkenheimer Co.
Nelson Valve Co.
* Pratt & Cady Co., Inc.
Schutte & Koerting Co.

Ventilating and Heating Apparatus
(See Heating and Ventilating Apparatus)

Voltmeters
(See Electrical Instruments)

Washers, Rubber
* Goodrich Co., B. F.
Manhattan Rubber Mfg. Co.

Washers, Leather
Schieren Co., Chas. A.
Williams & Sons, I. B.

Washers, Steel
* Auburn Ball Bearing Co.

Water Circulators, Filters, Gages, Heaters, Meters, Strainers, etc.
(See Circulators, Filters, Gages, Heaters, Meters, Strainers, etc., Water)

Water Columns
* American Steam Gauge & Valve Mfg. Co.
Ashton Valve Co.
Hughson Steam Specialty Co.
* Lunkenheimer Co.
Walworth Mfg. Co.

Water Purifying Apparatus
Dodge Mfg. Co.
Electric Water Sterilizer Co.
Harrison Safety Boiler Wks.
Scaife & Sons Co., Wm. B.

Water Tube Boilers
(See Boilers, Water Tube)

Water Wheels, Turbine
Holyoke Machine Co.
* Morris Co., I. P.

Waterproofing Materials
* Texas Co.

Wattmeters
(See Electrical Instruments)

Weighers, Coal
* Brown Hoisting Machinery Co.

Wheels, Polishing, Paper
Rockwood Mfg. Co.

Wheels, Self-Oiling
Fairmont Mining Mach. Co.

Whistles, Steam
* American Steam Gauge & Valve Mfg. Co.
Ashton Valve Co.
Brown Co., A. & F.
* Lunkenheimer Co.
Walworth Mfg. Co.

Winches
Lidgerwood Mfg. Co.
Shaw Electric Crane Co.

Wire, Aluminum
* Aluminum Co. of America

Wire, Brass and Copper
* Roebling's Sons Co., John A.

Wire, Flat
* Roebling's Sons Co., John A.

Wire, Iron and Steel
* Roebling's Sons Co., John A.

Wire and Cables, Electrical
* Aluminum Co. of America
* General Electric Co.
* Roebling's Sons Co., John A.

Wire Cloth
* Caldwell & Son Co., H. W.
* Roebling's Sons Co., John A.

Wire Rope
(See Rope, Wire)

Wire Rope Fastenings
Lidgerwood Mfg. Co.
* Roebling's Sons Co., John A.

Wire Specialties
* Roebling's Sons Co., John A.

Wiring Devices
* General Electric Co.

Wrenches
* Roebling's Sons Co., John A.
Walworth Mfg. Co.

Wrenches, Tap
Wells Bros. Co.

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The International Belting

Duxbak is popular in China because the shrewd Celestial has perceived the adaptability of this flexible water-proof belting to the variable climates of the different parts of his country. And as a consequence Duxbak has played a big part in the industrial and mining development of China during the last decade.

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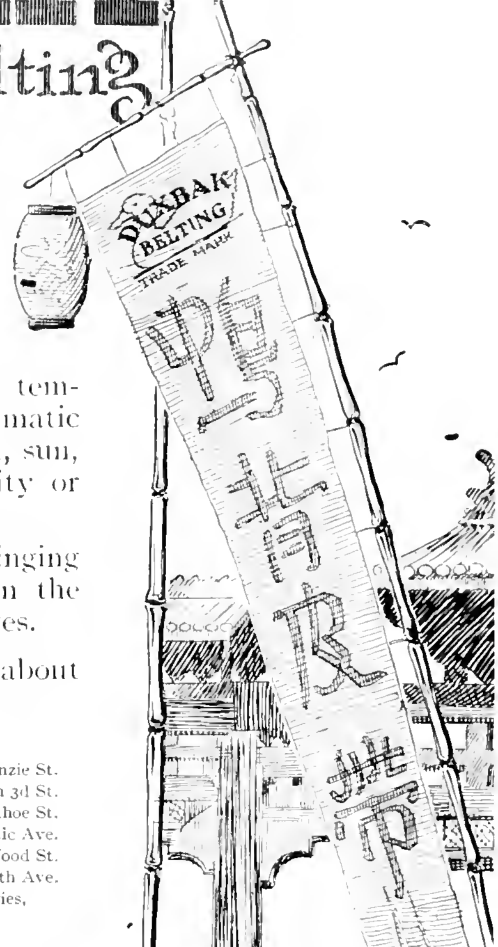

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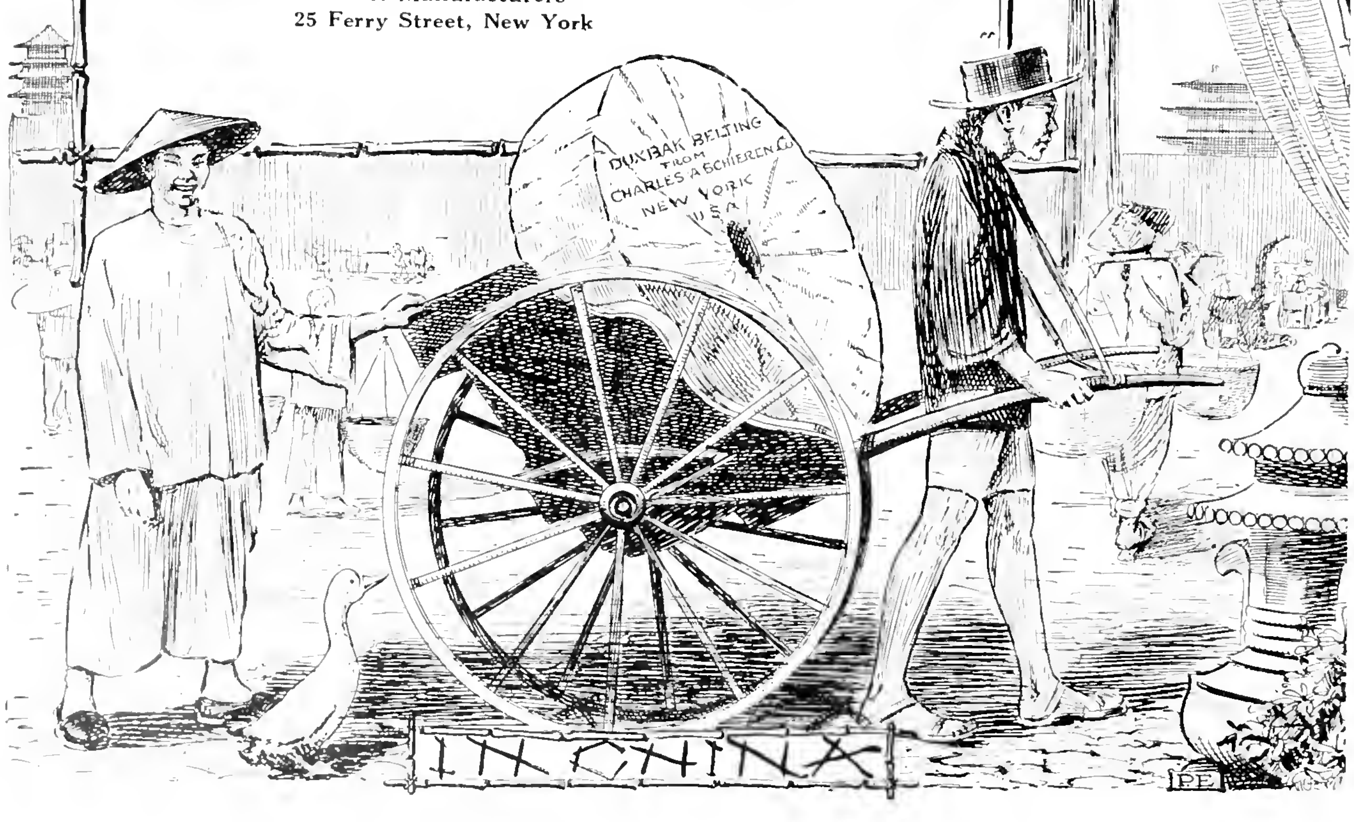
Chicago	128 W. Kinzie St.
Philadelphia	226 North 3d St.
Denver	1752 Arapahoe St.
Boston	641-643 Atlantic Ave.
Pittsburgh	205 Wood St.
Seattle	620 Fourth Ave.

Oak Leather Tanneries,
Bristol, Tenn.



ALPHABETICAL LIST OF ADVERTISERS

See Pages 39-48 for Classified List of Mechanical Equipment

Catalogue data of firms marked * appear in the A.S.M.E. Condensed Catalogues of Mechanical Equipment, 1914 Volume

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